# THE RAT
## DATA AND REFERENCE TABLES

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# PREFACE TO THE FIRST EDITION

For a number of studies on the growth of the mammalian nervous system made by my colleagues and myself we have used the albino rat. In the course of the work we frequently felt the need of referring to other physical characters of the rat to which the nervous system might be related. This led us to collect such data as were already in the literature and also led us to make further investigations. The facts gathered in this way have proved useful to us and are here presented in the hope that they will be useful to others also.

The plan of the presentation is simple. An introduction treats of the rat as a laboratory animal, indicates the methods of gathering the data, and also gives examples of our use of the tables. This is followed by an outline of the classification of the common rats and by a brief statement of the history of the rat since it arrived in western Europe.

The rest of the book falls into two parts. The first part deals with the domesticated albino rat—concerning which we have the larger amount of information.

The second part deals in a similar way with the wild Norway rat—the form from which the Albino has been derived. In connection with each part the several reference tables and the formulas employed for them and for the corresponding graphs, are given, and at the end of the book a list of papers on the rat is added.

In the two parts which form the body of the book the purpose is to present for the rat under normal conditions the fundamental observations—giving data and conclusions only. It is hardly necessary to add that in most directions our information is fragmentary.

For all the formulas which apply to the data coming from the laboratories of The Wistar Institute, I take pleasure in thanking my colleague, Dr. S. Hatai.

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For aid in the preparation of these pages I am also much indebted to those unnamed assistants to whose lot has fallen the greater part of the computations for the tables and whose devotion to their work has added a human interest to a task otherwise monotonous.

To the many authors whose results are here briefly cited or quoted in extenso I take the opportunity to express my obligations—very sincere obligations—for experience shows that such results come only by hard labor.

Many of the illustrations have been taken from the journals in which they were originally published and my thanks are due to the editors and publishers of these journals for the privilege of reprinting the illustrations here.

During the preparation of this book my immediate colleagues have given me encouragement and aid, and I cherish the hope that, should the occasion arise, both of these will be again forthcoming to help mend the gaps and rectify the errors which a close scrutiny of these pages is certain to reveal.

*Philadelphia, 1915.*

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# PROLOGUE

In order to get a background for studies on the growth of the nervous system of the rat, the available information on the growth of this animal was brought together and published in 1915, the first edition of this memoir. The time has now come for a revision and a word is in place concerning the changes which appear in this second edition, the significance to be attached to the method of presentation and the manner in which the data and tables can be used.

Touching the revision it suffices to say that the usual methods of elimination, correction and condensation have been followed, but nowhere are the changes made of a fundamental character.

Since 1915 our bibliography of the rat has increased by some 1300 titles, and these new contributions have furnished a considerable mass of information which has been incorporated.

Despite the fact that the aim has been to use only the best data touching any given point, and not to record the historical growth of knowledge concerning it, this second edition is inevitably larger than the first—a result to be deplored but apparently unavoidable.

In citing the new results it has been necessary to limit the entries almost entirely to fundamental data—to do more would have been to attempt an encyclopaedia.

When all is said, the question remains as to the significance and utility of the data and tables as here given. Appreciating that domestication has modifying effects, tables have been made separately for both the wild Norway and the domesticated Albino. Even as they stand these show differences between the two strains and these differences are regarded as due for the most part to the domestication of the Albino.

The pied strains, which are sometimes used for laboratory purposes, and which are also domesticated, seem to be very similar to the Albino. At the same time albinism is also a modifying factor and we know at present several characters in which the Albino differs from the Norway or the pied varieties. While there are differences between the pied and Albino varieties which require further study, they seem to be trifling in comparison with the more conspicuous modifications which have already appeared in the domesticated albino strain—as contrasted with the wild Norway.

During the past few years several laboratories have reported Albinos of large size, even larger than the wild Norways as commonly found. Here there comes to view the increase in body size which is so common a response in mammals under domestication.

There is a change also in the physiology of the Albino. Puberty now appears earlier in the domesticated Albino, not only in comparison with the wild Norway, but also in comparison with our records of 1915. Undoubtedly there are other instances of changes of this type not yet noted. Such changes mean that there is a drift in the characters of these domesticated rats, and suggest that after a century more of domestication, records of the structure and functions of the albino rat might distinctly differ from those with which we are here presented. Such a drift is sometimes designated as orthogenesis.

Returning to the difficulties which arise in the use of the tables here given, it is pertinent to enquire as to the significance of these, when, for example, it becomes necessary to deal with a rat one hundred days old, but which has a body weight two and a half times as large as the value tabulated for that age. Plainly, the age-weight relations do not agree with the values in the table.

Without going into details, inappropriate here, it may be stated in general that such an overgrown rat will have, in the case of characters related to body length or body weight, approximately those values which go with its size, despite the fact that it is young for its size, but these in turn will be modified where they are also correlated with age.

Pursuing the matter a step further, it seems highly probable that the number of cells in the nervous system is characteristic for the species and constant within the limits of biological variation. Hence variations in the weight of this system must depend mainly on the size of the constituent cells.

In other systems, characterized by the epithelial, glandular and connective tissues, there is probably much more latitude in the number of elements produced, but withal a concomitant variation in cell size as well.

In the growing rat there is at birth a phase in which cell multiplication is relatively active, though accompanied by the enlargement of those cells already formed.

In the nervous system cell formation comes to an end early and in the muscles it is slow after thirty days and diminishes with age probably in some of the other systems, although it persists throughout life in the epithelia. On a combination of these two processes of cell formation and cell enlargement depends the growth of the animal as a whole, accompanied, of course, by the accumulation of more or less inert material.

The overgrowth, such as was instanced earlier, appears to depend mainly on the precocious enlargement of the formed elements without a corresponding differentiation, which, if it occurred, would be accompanied by a relative change in the percentage of water and the chemical status of the tissues; since these changes are more closely correlated with the age than with the size of the rat.

While all this is in general true, nevertheless a shifting back of puberty in the female, which has been observed, indicates a real precocity of development in the ovaries and the associated structures. In this instance the chemical changes are also precocious. Thus age and size may vary widely, also age and the incidence of puberty, and hence in this latter case age and the phase of chemical development.

These statements indicate that there are fluctuations in characters both on age and on body weight, and also that there may be a drift or trend in the form and functions of the albino rat as domestication progresses.

What then is the relation of the data and reference tables to this state of affairs?

So far as these data are based on observations from our own laboratory they apply to a fairly uniform population of rats somewhat modified from time to time by food conditions. Further, it may be said that these rats show the characters commonly found in other laboratory colonies, but they represent neither the best animals nor those in the ideal condition, nor do they necessarily yield the values which will be found in Albinos ten years hence. Yet despite these defects the data and reference tables still have their uses.

The data in the reference tables reveal the form of the growth curves for the entire rat and its organs. In their essential features these growth curves are the same for rats of various sizes. The tables however have another and quite different use.

The case for the tables may be put in the following form. In a given research the test rats are compared with the controls and the differences from the controls give the amount of change. Here the controls furnish base line values, so to speak, and by them the values for the test rats are measured. In this instance reference tables are a luxury. Suppose however that two years later the same investigation is repeated and the changes in the test animals are again determined in the same way. When the two series of results are compared with each other it is important to know whether the control rats in both series agree in their characters. If, as is very possible, they do not agree, then it is a question which of the controls should be taken as the ultimate standard. This situation arises in all fields where measurements are made, and it is met by having accepted standards to which the individual measuring instruments (here the controls) are referred. It may happen then that the controls in the earlier research show a character ten per cent above the table values, while in the later research, it is ten per cent below. In any effort to collate the two series of results this difference between the controls must be taken into consideration.

Such differences may not be always significant as influencing the experimental results, but on the other hand they may be of great importance, and recognition of them can thus facilitate the interpretation of differences found in two successive investigations or in those made in other laboratories where other strains of rats have been used. The tables and data offer then base line values to which those of the controls used in any investigation may be referred.

Further, the individuals in the group of controls, no matter how carefully chosen, will differ from the individuals in the test group. They cannot therefore be directly compared with one another for the values of any character under consideration, but the determination of their respective deviations from the corresponding table values furnishes at once a basis of comparison.

As to these table values themselves, one hastens in the first instance to disclaim the suggestion that they furnish standards of the same type as are to be had in the physical sciences. In the very nature of the case such accuracy and constancy is unattainable, for all animals at all times are in a state of flux. The data must be statistical and always carry a probable error.

Really all that can be said in the way of apology for the use of the values here given, as basal, is that "once upon a time" there was a group of albino rats living under moderately favorable conditions which had the various characters with the values here recorded.

All the present tables might therefore be replaced by new ones which would show a somewhat different series of values, and if two such sets of tables were available, the best criterion for preference would lie, I believe, in the degree to which the values given approximated a position intermediate between the values reported at the time from different laboratories and for different strains.

In discussing the use of the reference tables, emphasis has been laid on the cases in which the observed values are for one reason or another distinctly different from the table values. This is particularly common in the case of the glandular system and in the storage organs, while on the other hand, skeletal relations, such as the lengths of the limb bones to the length of the body, show a higher degree of constancy. Indeed, when one takes at random an albino rat of moderate size and compares the values for its characters with those given for the body length or body weight in the appropriate tables, one finds to-day in the case of Albinos from our own colony a good agreement, between the observed and the table values, for a large number of characters.

On the other hand, in some characters a distinct shift has occurred. For example, the weight of the thyroid gland in rats from The Wistar Institute Colony is to-day distinctly below that given in the tables.

This compilation is therefore put forth in the hope that the reference data here given can be used to control and to make comparable the results of investigations carried out at different times and places and with different strains, and also with the hope that they may furnish a set of records by which further changes in the albino rat due to continued domestication can be measured.

The reference tables have been retained largely unaltered because the several determinations were mainly on the same series of rats—and any particular revision for one or more organs would introduce a disharmony in this group of records.

A few words touching the qualifications of the rat as a laboratory animal may be added.

The larger part of the information contained in this memoir has come from the study of the domesticated albino rat, which is a mutant from the wild Norway, but the general biology of all the color varieties of this species is similar.

The wild Norway rat is cosmopolitan and its albino variety is also found in all countries where small pets are kept. It is omniverous, with a range of diet as wide as that of man. It breeds freely at all seasons but most actively in the spring and early fall. The litters are large and the sexes appear in about the same ratio as in man—so that control and test animals of like sex may be had from the same litter—thus giving the closest relationship.

The albino rat thrives when inbred, provided there is selection for vigor. In a revolving cage it runs long distances voluntarily—much to the advantage of its general health. To training, it responds readily.

If the life span of three years in the rat is taken as equivalent to 90 years in man, it is found that the growth changes in the nervous system occur within the same fraction of the life span (i.e., at the equivalent ages) in the two forms. What is true for the nervous system is also probably true for some of the other systems and this makes possible the cross reference of the results from the two species, with a high degree of precision.

It is now appreciated that the mammals associated with man, of which group the rat is a good example, are very responsive to environmental changes. The sensitiveness which they show and the speed with which the responses occur, require to be kept in view in all work—observational or experimental—on the living animal. This is a matter on which it is hardly possible to lay too great emphasis.

Such responsiveness is an advantage when it is sought to induce changes, but a distinct disadvantage when the constancy of the control animals is desired.

The critical periods in development are well marked, and birth, weaning and puberty, though somewhat differently spaced in the span of life, bring with them the same changes that appear in man.

Finally, in the case of the rat, the wild form, the Norway, is generally available for comparison with the domesticated Albino, and thus the modifications induced by captivity and domestication can be readily observed.

Some of the effects of domestication are already recognized, but the matter calls for further study. In this connection it is not without interest to note that the Albino rat has probably been under domestication for less than a century, whereas, by contrast, most of the common domesticated animals have been associated with man for hundreds or even thousands of years, and in most instances the wild types from which they came are either doubtful or hard to obtain.

In enumerating the qualifications of the rat as a laboratory animal, and in pointing out some of its similarities to man, it is not intended to convey the notion that the rat is a bewitched prince or that man is an overgrown rat, but merely to emphasize the accepted view that the similarities between mammals having the same food habits tend to be close, and that in some instances at least, by the use of equivalent ages, the results obtained with one form can be very precisely transferred to the other.

It is proper to recognize, however, that, considered from the laboratory standpoint, at least three major deficiencies are presented by the rat. Its small size makes some types of experimental work either difficult or impossible. Its resistance to various forms of infection, diphtheria and tuberculosis, for example, makes it unsuitable for certain classes of studies, while its susceptibility to a form of lung infection, sometimes called rat pneumonia, has proved thus far a serious obstacle to studies on senescence. It is possible that this last defect may be remediable, but the others are inherent.

In assembling this information the aim has been to give, in tabular form especially, such data as can be presented in quantitative terms and also such as are closely related to age and to the critical periods of development, since the experimental results obtained often depend in such an intimate way on the exact condition of the animal at the time of the test.

# THE RAT

## INTRODUCTION

The Norway rat, Mus norvegicus, is one mammal now easily obtainable both wild and as a domesticated form. This latter is represented by either the Albino or the pied rats so common in our laboratories.

The Albinos are clean, gentle, easily kept and bred, and not expensive to maintain. They are omnivorous, thriving well on table scraps. The span of life is about three years and breeding begins at about three months. Furthermore the species is cosmopolitan. The litters are large and may be had at any season. The young are immature at birth. The domesticated Albino crosses readily with the wild Norway. The rat, both wild and domesticated, takes exercise voluntarily and is susceptible to training. It is also highly resistant to the usual wound-infecting organisms. For a number of lines of study therefore, the rat is peculiarly suitable.

Through the researches of a host of investigators both in this country and abroad, there has been gathered a considerable body of data applying to the weight and size of the domesticated Albino rat and its parts, as well as some similar data applying to the wild Norway rat, the parent species. It is the body of facts so gathered that it is our purpose to present, as far as possible in tabular form.

Attention should be called to the fact that the observations presented in the tables have been made mainly on rats in the first year of life and but rarely on those which are older. It follows from this that the data apply to the rat in its most vigorous period and do not give information that can be used for the study of old age.

Since the quantitative data appearing in the tables are biological, they naturally exhibit more or less variability and reflect in each instance something of the conditions under which they have been obtained. It follows therefore that they must not be expected to possess the precision of physical or chemical determinations. Nevertheless, so long as the values here presented are not mistaken for absolute standards representing ideal or final determinations, they may be used with advantage.

Most of the matter presented is taken from researches already published in full, but in a few instances data from work in progress have been included also. In the latter instance the author's name is followed by (MS with date).

In a few of the tables already published, mainly from our own laboratory, it has been found necessary to make corrections, so that when the tables here printed do not agree with the originals, it is to be assumed that the changes are due to revision.

Owing to the absence of data for the normal animal or to the failure of the authors to express their results in a quantitative form, much of the literature which is cited does not appear in the text. Such papers however often contain valuable information on either the Albino or Norway rat and the citation of them in the bibliography serves to indicate the range of the studies in which this animal has been used.

Extensive reference tables have been computed for the various characters only as these appear under normal conditions, while the modifications which may be experimentally induced in these characters are merely mentioned or presented very briefly.

In a number of cases the results are represented by both graphs and tables. The purpose of the graphs is merely to furnish a general view of the form of change which occurs, while for the exact values, the tables must always be consulted. In those tables which are based on size, the body length of the rat, because it is least subject to incidental variations, is the measurement to which the others have been referred.

It is recognized however that some of the characters are functions of age and in that case it is of course necessary to know the age of the animal in order to obtain satisfactory results.

All of the longer tables are based on formulas. These formulas are those for the graphs which most closely fit the observed values—and their utility lies in giving precision to the values obtained and in making possible interpolations:—as a rule however they cannot be used for extrapolation. In this connection determinations of the normal variability are always wanted, yet although this need has been met in a measure, it is far from being satisfied.

The significance and general use of these tables has already been set forth in the Prologue and need not be dealt with here.

One use of the tables when these are based on age may however be emphasized. The comparison of the experimental results obtained on animals with the corresponding results on man has heretofore been difficult because of the absence of a good basis for comparison. We have found reason to assume that in the case of the rat the postnatal span of life of three years is approximately equivalent to the span of ninety years in man—or to put it another way, that the rat grows thirty times as fast as man. This ratio appears to hold for fractions of the span of life, as well as for the entire span. All of the data for the Albino, based on postnatal age, may therefore be compared with the corresponding data for man, if the time intervals are taken as one for the rat to thirty for man.

Finally it is desirable to explain here a seeming inconsistency in the arrangement of the material presented. In the Preface the statement is made that Part I deals with the Albino rat, while Part II deals with the Norway. So far as all of the important tables and records are concerned this statement does not need revision.

It has been found however in arranging the literature that it would prove most useful to include in Part I all of the incidental and general observations on the wild Norway, on the ground that these applied to the entire species, and to reserve for Part II the more precise data which apply to the wild Norway, as contrasted with the domesticated Albino.

The reader therefore will find in the literature cited in Part I papers referring to M. decumanus, M. norvegicus and Epimys norvegicus as well as to the Albino (M. norvegicus albinus or var. Albino), sometimes designated the 'white' rat.

As will be pointed out in the section on The Early History of the rat, there is one more complication in this connection. Through an error, unfortunately perpetuated by some of the natural histories, the common Albino has been described as an Albino of the house rat—Mus rattus.

It thus happens that in some of the papers cited it is reported that the observations had been made on Mus rattus or ratus (sic), the word albino being sometimes added—sometimes omitted. In a few instances it is impossible to determine whether M. rattus is used for the Albino or whether the house rat was really studied.

In forming a judgment on these cases it must be kept in mind that for the last half century the house rat has been rare and hard to obtain both in western Europe and in the northern United States, so that unless the author gives good evidence for the name he has employed, it becomes highly probable that he was working with some form of the Norway. For these reasons it has been found most convenient to include also in Part I all the references to the house rat (Mus rattus).

## CLASSIFICATION AND NOMENCLATURE OF THE COMMON RATS

Up to 1881 Mus (Linnaeus, 1758) was used as the generic designation for both the rats and mice. In 1881 Trouessart proposed the subgenus Epimys for the larger forms, the rats, reserving Mus for the smaller forms, the mice—Mus musculus being the type. In 1910 Miller established the use of Epimys for the rats. By the law of priority however Epimys must in turn be displaced by Rattus (Fischer, 1803) as pointed out by Hollister ('16).

In the pages which follow however the designation Mus has been retained for the rat—as the older term is well understood, while the new terms—Epimys and Rattus—are at present generally unfamiliar.

The following condensed citations of the place of the original descriptions—with some of the associated references—serve to give a brief history of the nomenclature.

MUS, Linnaeus, 1758
  EPIMYS, Trouessart, 1881—Miller, 1910.
  RATTUS, Fischer, 1803—Hollister, 1916.
    —norvegicus, Erxleben (1777 descr. orig.)
    —*decumanus*, Pallas (1778)
      —*aquaticus*, Gessner, 1551.
      Cosmopolita; ab Asia occident. in Europam a navibus translat. et inde in omnes Orbis Regiones.
    —rattus, Linnaeus (1758 descr. orig.)
      Cosmopolita; ab Asia occident., in Europam a navibus translat., et inde in omnes orbis regiones.
    —alexandrinus, Geoffroy, (1812 (or 1829 vide Sherborn, 1897) descr. orig.)
      Asia minori, Arabia, Aegyptus, Algeria, etc.
      Italia, Hispania, Gallia merid.—orient. et occid., et inde in omnes orbis regiones.

Since attention was called to Erxleben's description in 1777 (Rehn, 1900) his specific name, norvegicus, as the designation for the common brown or Norway rat, has been used in place of decumanus (Pallas, 1778). The designation norvegicus is now well established and will be used here.

There seems no question that Mus rattus and Mus r. alexandrinus are related to one another as color varieties of the same species (de l'Isle, 1865; Millais, '05) and they are so considered in the following pages. For convenience we shall use the term Norway or Norway rat for Mus norvegicus—and the term House rat as a general designation for both Mus rattus rattus and M. rattus alexandrinus unless the occasion calls for the precise name.

Albinos of the house rat have without doubt existed in the west of Europe at one time or another ever since this form overran that region (Topsell, 1658) but, despite earlier reports to the contrary, neither Albino nor pied specimens of the house rat are to be found in our larger museums.

At present Albinos of the house rat appear to be not uncommon in India (Lloyd, '12) where the house rat population is large. In western Europe and other regions in which the house rat population is waning, a careful search by several investigators during the last decade has failed to reveal a living albino specimen.

At the present time, therefore, the Albino of Mus norvegicus is the only albino variety generally found. In these pages this form is designated Mus norvegicus albinus—when the name is given in full, but where possible the single word Albino is used for it.

When the albino variety is mentioned here the strain as commonly reared is the one meant. As a rule this strain is far removed from its wild ancestor and moderately inbred. It may be conveniently designated as the common albino strain.

In the colony at The Institute, we have in addition to this, a closely inbred strain reared by Dr. King. Strains of "extracted" Albinos are maintained in some laboratories. These latter are the Albinos descended from the $F_2$ generation of hybrids from the wild Norway and the domesticated Albino.

During the first few generations after their appearance, these extracted Albinos show clearly certain Norway characters, which distinguish them from the rats with a longer albino ancestry. With the peculiarities of either the inbred or of the extracted strain, we are however not specially concerned.

While all Albinos breed true as to color, the composition of the gametes is undoubtedly different among them in accordance with their remote ancestry. Mudge ('10) recognizes thirteen gametic types. The gametic dissimilarity of various Albinos in respect to hair color is shown by the fact that in breeding tests (Doncaster, '06 and Mudge, '10) Albinos extracted from ancestors with characteristic differences in pigmentation will reveal their origin by producing, when crossed with the pigmented strain, characteristically pigmented descendents, the markings of which can be predicted.

We are naturally concerned with the gametic composition of the general population of Albinos constituting the different colonies to-day. As these colonies stand, the Albinos composing them do not form a strictly homozygous population, even from the standpoint of color, since in subsequent crosses with pigmented forms they give offspring with different color markings according to their several latent characters.

On the other hand it may be fairly said that as yet we have no evidence for any correlation of the somatic characters so far studied, with those slight differences in gametic composition of the common albino strain which we can recognize. It is to be noted moreover that the difficulty which thus appears in the case of the albino rat repeats itself for other mammals also, and therefore it does not constitute a peculiarity of this animal.

### CLASSIFICATION : REFERENCES

Alston, 1879–1882. Blasius, 1857. Doncaster, '06. Erxleben, 1777. Fischer, 1803. Geoffroy, 1812. Gesner, 1551. Hatai, '07. Hollister, '16, '16 a. l'Isle, 1865. Linnaeus, 1758, 1766. Lloyd, '12. Longman, '16. Millais, '05. Miller, '10. Mudge, '10. Pallas, 1778. Rehn, 1900. Topsell, 1658. Trouessart, 1881, 1897, '10. Tullberg, 1900.

### EARLY RECORDS AND MIGRATIONS OF THE COMMON RATS

The common wild rats in the United States usually live in close association with man. There are two species of these, both of which have been introduced from Europe. These are Mus rattus (Linnaeus, 1758; 1766 = Mus rattus rattus, Millais, '05) together with its gray form, Mus alexandrinus (Geoffroy, 1812; = Mus rattus alexandrinus, Millais, '05) and Mus norvegicus (Erxleben, 1777 = Mus decumanus, Pallas, 1778). This last species is our common gray, brown or Norway rat. In addition to these, all of which are wild, there is a fourth form—the albino rat (Mus norvegicus albinus) a variety of Mus norvegicus (Hatai, '07) which is known at present only as a domesticated strain (Donaldson, '12 b).

Mus rattus—the house rat—the first species described in western Europe, is probably indigenous to India.[1] As now found, the melanic form of Mus rattus (or Mus rattus rattus, Millais) the 'black' rat, is more frequent in the colder latitudes, and Mus rattus alexandrinus (Millais) the gray form (the 'roof' or 'snake' rat) in the warmer latitudes, but the two are not sharply segregated. At the same time both of these seem more dependent on warmth, or more resistant to it, than the Norway rat.

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[1] Fossil remains of the rat (Mus rattus) are reported in the pliocene in Lombardy (Cornalia, 1858) and in the quaternary at Molina di Anosa near Pisa (Forsyth Major) and again from the pleistocene cave deposits of the island of Crete (Bate, '12). This species appears in glacial times (Diluvialzeit) and in association with man in the remains of the Lake dwellers in western Germany and in Mecklenburg (Blasius, 1857). It is reported also from the diluvial deposits in Bohemia (Woldřich, 1880).

Although we shall have little to say in the following pages about Mus rattus, yet it is desirable to give its history in order to obtain the proper setting for Mus norvegicus, at present the dominant species. The geological evidence just given indicates the very early appearance of the house rat in Europe but our records of its migrations all fall within the present era.

The history of the early migrations is of necessity vague and incomplete, and even in the later times when dates are given it must be remembered that such animals might have been present for some time without appearing in numbers sufficient to cause comment.

There is no good evidence that the Greeks or Romans before the present era were familiar with the rat as a pest, and therefore, even if present, it was probably not abundant at that period on the shores of the Mediterranean.

The history of the house rat from the earliest times to the eleventh century makes an interesting archaeological study, but the conclusions which may be drawn from the scanty records and indefinite allusions are too uncertain to be of value for our present purpose and we therefore pass directly to the later authors.

Possibly as far back as the migration of the hordes (Völkerwanderung, 400–1100 A. D.) and later in consequence of the increasing use of trade routes with the East, the house rat entered western Europe in appreciable numbers (Hehn, '11). It is reported to have arrived there after the twelfth century (Keller, '09, citing Theodoros Prodromos). Giraldus Cambrensis,[2] (1146?–1220) records several anecdotes concerning it.

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[2] Albertus Magnus (d. 1280) is sometimes cited as having mentioned the black rat. This is not correct. A. de l'Isle (1865) has pointed out that the description in question applies to the dormouse—Myoxus quercinus.

As the Norway rat did not reach western Europe until 1727–1730 it follows that the European rat of the middle ages, the rat of the legends, of the Pied Piper[3] (1284), of the great plagues (before 1700) and of the early anathemas against vermin, was Mus rattus.

The species first brought to South America on the ships of the very early explorers was Mus rattus (Vega, 1609; de Ovalle, 1646). Pennant (1781) gives 1544 as the date of arrival in Peru.[4] We have also a notable instance of a plague of these rats in the Bermudas in 1615 (Lefroy, 1882).

Of the two species in question, Mus rattus is alone recognized by Linnaeus in his Fauna suesica 1746, and in his Systema (1758 and 1766). It does not concern us here to follow the history of Mus rattus in the United States further than to say that this species only (represented by the two forms) was present up to the time of the arrival of the Norway rat in North America toward the end of the eighteenth century, and that Mus rattus rattus—the black rat—is still found in a number of scattered localities in the northern United States, while in the southern states, Mus rattus alexandrinus is much the more common. It does not appear that either of these forms has ever penetrated far into the interior of the country.

Turning to the cosmopolitan Mus norvegicus—the species at present established in China, Japan, India, western Europe and temperate North America—we find that the historical record of its movements, though by no means complete, has the virtue of being recent.

v. Gesner (Historia animalium, 1551) mentions a Mus aquaticus which appears to be the form now called Norvegicus, but apparently he himself had never seen it.

According to Pallas (1831) the Norway rat invaded Europe from the East early in the eighteenth century and was observed in large numbers crossing the Volga in the Russian province of Astrakhan. Pallas gives 1727 as the year of this migration. In view of other dates, this can hardly be the date of the first invasion. The Norway rat reached England—probably by ships—about 1728–1730 (Donndorff, 1792) and was soon designated the 'Hanover' rat by those who wished to connect the misfortunes of the country with the recently established house of Hanover.

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[3] It may be noted in passing that the ancient inscriptions in Hameln relating to the Pied Piper do not mention the rat (Meinardus, 1882).

[4] Pennant (1781) says there were no rats in South America before the time of Blasco Minez. Minez is evidently a misprint for Núñez; Blasco Núñez being the first Viceroy of Peru, from 1544–1546.

There is however no reason to suppose that the Norway rat had yet reached Germany and the name has a political rather than a scientific interest.

In 1750 the Norway rats are reported (Donndorff, 1792) to have reached eastern Prussia and in 1753 they were noticed in Paris (Donndorff, 1792). Their early distribution to other localities in Europe need not be recounted, but there is evidence that they spread rapidly and soon displaced more or less completely the Mus rattus which had preceded them.

This historical sketch shows that the migration of Mus rattus into western Europe antedated that of Mus norvegicus certainly by some six hundred years, but the Norway rat being the more pugnacious and powerful species has become dominant wherever it has followed the earlier form.

This dominance is undoubtedly due in part to these characters of the Norway, but it seems probable that the progressive disuse of wood as a building material has been a factor also (Przibram, '12).

We find however that in many places, both in Europe and the United States, where the house rat was thought to have been exterminated, it still survives in small numbers.

The arrival of the Norway rat on the north Atlantic seaboard of the United States is usually given as 1775 (Harlan, 1825). The exact date, though of interest, is hardly important for our present purpose.

Mus rattus was already in possession, but in the course of the years, how rapidly we do not know, the Norway rat became the dominant form in the northern latitudes of this country—moving along the trade routes to all points which furnish a continuous food supply and a moderate summer temperature.

In the present connection our interest in the Norway rat is due mainly to the fact that the common albino rat (M. n. albinus) kept as a pet or laboratory animal, and concerning which we desire all possible information, is a variety of the Norway rat. This relationship is shown not only by the usual methods of comparison, but also by the haemoglobin crystals (Reichert and Brown, '09) the shape of skull (Hatai, '07 c) and the fact that the two forms interbreed freely.

Concerning the place and time of origin of the albino strain there is little information at hand. Allusions to albino rats before the time when the Norway rat appeared in Europe clearly show that there must have been an albino strain of Mus rattus. What we know of the present distribution of Albinos of Mus rattus has been given on pages 5 and 6 in the preceding chapter.

By some curious slip however, many of the natural histories and books of reference speak of the common Albino as an Albino of Mus rattus. This of course is not correct, but owing to the confusion thus early introduced, it is difficult to trace the history of the present albino variety[5] of the Norway.

We do not know whether the common albino variety had a single or multiple origin, or whether the colonies found in Europe (Rodwell, 1858) are directly related to those now existing here. Moss, 1836, mentions Albinos in or near Bristol, England about 1822. Judging from the way in which the Albinos of other species arise, we may safely assume that the present strain is derived from one or more albino mutants or sports (Hatai, '12). These must have been captured and the albino descendents segregated and kept as pets, as at present[6] there is nowhere to be found an established colony of Albinos living in open competition with the common Norways or with forms of Mus rattus, but all of the colonies are maintained practically under conditions of domestication.

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[5] Unfortunately there is one more complicating circumstance—namely, the existence of a melanic variety of Mus norvegicus. This melanic variety is often mistaken for Mus rattus rattus because of its color, and this leads to errors of statement concerning the distribution of Mus rattus and also concerning the ability of the two species—rattus and norvegicus—to interbreed. They are in fact mutually infertile (Morgan, '09) (The Hagedoorns, '17). The number of incidental allusions to this melanic variety of norvegicus shows its occurrence to be widespread. See: Edwards, 1871, 1872. Hamy, '06. l'Isle, 1865. Lapicque and Legendre, '11. Schäff, 1891. Webster, 1892.

[6] Rodwell, 1858, page 10, mentions what may have been a colony of Albinos living wild at the Ainsworth Colliery near Bury, England.

In the northern United States, except along the water front of the larger ports, where the house rat arrives from time to time on vessels, we have therefore to deal almost exclusively with the Norway rat. The Norway has been in this region probably not more than a hundred and fifty years. Though living wild, it is more or less dependent on the food conditions found where man is established. The familiar Albino—Mus norvegicus albinus—is a sport derived from the wild Norway, and is the form on which most of the investigations here presented have been made.

It is important to note that in their general physical characters both the wild Norways and the Albinos of western Europe are similar to the corresponding forms in the United States (Donaldson, '12, and '12 a).

On the other hand the Hagedoorns ('17) report that the wild Norway in the Island of Java shows much variability.

### EARLY RECORDS AND MIGRATIONS : REFERENCES

Albertus Magnus, b. 1206–d.1280. Barrett-Hamilton, 1892. Bate, '12. Baumgart, '04. Blasius, 1857. Borcherding, 1889. Campbell, 1892. Cantoni, 1880. Clarke, 1891. Cornalia, 1858–1871. Cornish, 1890. Donaldson, '12 b. Donndorff, 1792. Edwards, 1871, 1872. Erxleben, 1777. Fischer, 1869. Geisenheymer, 1892. Geoffroy, 1812. Gesner, 1551. Giraldus Cambrensis, b. 1146?–d. 1220. Godman, 1826–1828. Gourlay, '07. Hagedoorn and Hagedoorn, '17. Hamy, '06. Harlan, 1825. Hatai, '07, '07 c, '12. Hehn, '11. Hossack, '06, '07, '07 b. l'Isle, 1865. Keller, '09. Keller-Zschokke, 1892. Lagerlöf, '07. Lantz, '09. Lapicque and Legendre, '11. Lefroy, 1882. Liebe, 1891. Lindner, 1891. Linnaeus, 1746, 1758, 1766. Lloyd, '10, '12. Lönnberg, '06. Löns, '08. Luke, '17. Major (see Baumgart, '04). Meinardus, 1882. Messer, 1889. Middendorff, 1875. Millais, '04, '05. Mojsisovics, 1897. Morgan, '09. Moss, 1836. Murphy, '17. Murray, 1866. Ovalle, 1646. Pallas, 1778, 1831. Pennant, 1781. Prodromus, Theodorus (see Keller, '09). Przibram, '12. Reichert and Brown, '09. Rodwell, 1858. Schäff, 1891. Sulzer, 1774. Vega, 1609, 1688. Ward, '06. Webster, 1892. Woldřich, 1880–1884.

*General similarities in western Europe and America.* Donaldson, '12, '12 a.

*Rattenkoenig.*

Ahrend, '03. Demaison, '06. Dollfus, '06. Koepert, '04.

# PART I

## ALBINO RAT—MUS NORVEGICUS ALBINUS

# CHAPTER 1

# BIOLOGY

1. Life history. 2. Span of life. 3. Puberty. 4. Period of gestation. 5. Superfecundation—Superfetation. 6. Fertility. 7. Sex ratio. 8. Recognition of sex. 9. Body weight according to sex. 10. Behavior. 11. Comparison with man.

1. *Life history.* The rat breeds at all seasons of the year, but most readily in the spring, and judging by other animals, it is probable that those born at this season tend to be more vigorous. The albino rat is born blind, hairless, with a short tail, closed ears and undeveloped limbs. It responds to contacts and olfactory and taste stimuli, utters a squeaking sound and is capable of some locomotory movements which are a combination of wriggling and paddling. The head is always searching. The young can find their way back to the mother at about ten days of age (Watson, '03).

The ears open between 2½ to 3½ days of age but there is a cellular plug in the meatus which may persist for a short time longer.

According to Wada ('23) rats can hear at from 9–12 days of age. The earlier date is exceptional. Lane ('17) reports 12 days as the earliest age at which he obtained a response.

The rat is a swimming animal. The newborn young sink. At two days they make paddling movements mostly with the forelegs, but remain below the surface. At eight days they swim with the nose above water, while previous to this they have been swimming with the nose more or less submerged.

The eyes open at from the 14th to the 17th days, most often on the 15th or 16th. King has also observed that in a given litter the eyes of the females usually open some hours before those of the males. For some seven days more, i.e., up to the time when the young rats are 21–22 days of age, they are dependent on the mother. After this they may be weaned, although if permitted, the young will depend partly on the mother for some days longer.

This adjustment of relations fits with the fact that the female may be impregnated one or two days after casting a litter (Kirkham, '10; Kirkham and Burr, '13) and since the gestation period is about 21.5–22.5 days, this would enable the female to free herself from the first litter before the second one was born. As will be pointed out later, the gestation period may be prolonged in nursing animals.

When the young rats become habituated to independence, i.e., at about 25 days, they enter on a period of activity, the phases of which have been followed by Slonaker ('07, '12). In the cases which he observed, it was found that increasing age was accompanied by increasing activity up to the age period of 87–120 days, after which the activity declined.

On the assumption that the span of life in man is thirty times that of the albino rat (Donaldson, '06) this age of greatest activity would correspond to the age of 7.5–10 years in man.

As shown by the records of activity (Slonaker, '12) the albino rat is nocturnal. This habit can be modified more or less by feeding or by disturbance during the day time.

The measure of activity in the cases observed by Slonaker was the number of turns of the revolving cage in which the the animal was kept, the cage being set in motion by the voluntary running or other movements of the animal, and the revolutions being automatically recorded. In the case of four rats kept in separate revolving cages from 30 days of age until natural death, the following records of activity were obtained (Slonaker, '12). Table 1.

This table shows not only great variability in the total performances, but also for the one female a record of over five thousand miles in a little less than three years. On the average, three-fourths of the total distance is run before the rat has reached middle life, and the last months of old age are always marked by greatly lessened activity (see Behavior—activity and exercise, page 31).

In observations on activity in other laboratories the superior performance of the female has generally appeared. Dr. Wang ('23) has pointed out that activity in the female is rhythmic and correlated with the oestrous cycle, showing a maximum at oestrus.

TABLE 1

*Total number of miles run during life*

| AGE IN MONTHS AT DEATH | RAT 1, M. MILES | RAT 4, M. MILES | RAT 2, M. MILES | RAT 3, F. MILES |
|---|---|---|---|---|
| 25 | 1265 | | | |
| 26 | | 1391 | | |
| 32 | | | 2098 | |
| 34 | | | | 5447 |

*Determination of age.* To determine the approximate age of a rat when the date of conception or of birth is not known, there are a few changes and events which are useful. The references for these data will be found at the appropriate places in the text.

| | |
|---|---|
| Before birth: | |
| Eyelids of fetus fuse at | the 17th day |
| After birth: | |
| Ears open at | 2½–3½ days |
| Incisors erupt at | 8–10 days |
| Eyes open at | 14–17 days |
| Hair obscures genitalia | 16 days |
| 1st molar erupts | 19 days |
| 2nd molar erupts | 21 days |
| 3rd molar erupts | 35 days |
| Testes descend | 40 days |
| Vagina opens | 72 days |
| The menopause occurs at | 15–18 months |

In rats more than a year old the angle of the nasals with the frontals increases, giving a "Roman nose" effect. Under unusual care and feeding the events preceding puberty tend to come earlier and the changes characteristic of old age are deferred.

2. *Span of life.* On the assumption that dating from birth, the life span of the albino rat is three years, then such a rat may be regarded as corresponding to a man of ninety years.

So far as this assumption has been tested it appears to be a useful approximation.

Slonaker ('12, '12a) working at Leland Stanford University under the favorable climatic conditions of California, has made some direct tests.

Four albino rats living in revolving cages attained an average age of 29.5 months, while three control animals reared in stationary cages, but under conditions otherwise similar, attained an average age of 40.3 months. In all these cases, death was reported as due to 'old age.'

The average age of these seven individuals was about 34 months, while the greatest age, attained by one of the controls, was 45 months. The three controls all lived longer than any of the four in the revolving cages. It appears from this that living in the revolving cage shortened the span of life—an unexpected result.

The oldest rat reported by Slonaker would be equivalent in age to a man of 113 years.

During the last few years the oldest rats of both sexes in the Institute colony have attained three years and somewhat over—and with the present conditions it is probable that still greater ages will be reached occasionally.[7]

3. *Puberty—ovulation—oestrous cycle—menopause.* Sexual maturity, as indicated by the structure of the gonads, usually occurs in both males and females at the age of about two months or less.

According to Long and Evans ('22) the vagina opens at about 72 days (range 34–109 days) and ovulation begins at about 77 days (range 45–147 days). These observations are based on 200 rats.

A tendency of the females to breed at an earlier age than they did in 1915 has been noted in The Institute colony and the same has been reported from other laboratories. In a specially well fed and tended group, Greenman and Duhring ('23) have had exceptional females cast their litters at 55 and 57 days of age. These rats therefore became pregnant at 33 and 35 days respectively.

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[7] Instances of unusual longevity occur. Thus an albino used for show purposes was kept by Mr. Harris for 4 years and 8 months and was assumed to have been about a year old when purchased in Shanghai in 1913. (Archives of The Wistar Institute.)

In the breeding Albino it is found that impregnation most readily follows 24 hours after a litter has been cast. This accords with the time of ovulation (Kirkham, '10; Sobotta and Burckhard, '10; Kirkham and Burr, '13). During the breeding period the female ovulates at intervals of 5 days or slightly less (Long and Evans, '22), but only from April to October do the females regularly ovulate 15–24 hours after parturition.

The menopause commonly appears at the age of 15–18 months (equivalent to 38–45 years in man). Particularly good conditions of food and care tend to delay the appearance of the menopause (Greenman and Duhring '23).

*Oestrous cycle.*[8] Long and Evans ('22) observed the oestrous cycle to extend from three to thirteen days or more, with a well marked tendency to be about five days (4.8)—table 2.

In a later study Evans ('24 MS.) determined the proportion of the short or normal cycles in two colonies of Albinos as compared with the gray and white cross of Long and Evans, with which the original studies were made. The results are given in table 2a and show a very fair agreement among the three series.

By using the method of vaginal smears, loc. cit. p. 41, five stages in the oestrous cycle have been determined as shown in table 3.

In table 4 is given the number of hours for these several stages in a cycle of something over four days.

The fifth stage or dioestrous interval in these instances extends for 48 hours or more.

The length of the first post partum oestrous cycle when suckling is prevented, was found to be from 5–7 days, and when the young were nursed less than 12 hours, somewhat less than seven days.

[8] Under the title of "The oestrous cycle in the rat and its associated phenomena," Long and Evans ('22) have recorded a very complete series of observations. For this study pied rats (black and white) were used, but the results are applicable to the Albino and several of the tables and conclusions are here cited.

4. *Period of gestation.* The gestation period of the non-lactating albino rat is usually from 21–22 days.

TABLE 2

*Table of observed instances of oestrous cycles of various lengths*

| LENGTH OF CYCLE IN DAYS | NUMBER OF INSTANCES | | | | |
|---|---|---|---|---|---|
| 3 | 92 per cent | 65 | | 92 per cent | Average 4.8 days |
| 4 | | 789 | 82 per cent Average 4.6 days | | |
| 5 | | 634 | | | |
| 6 | | 233 | | | |
| 7 | | 69 | | | |
| 8 | | 60 | | | |
| 9 | | 30 | | | |
| 10 | | 24 | | | |
| 11 | | 16 | | | |
| 12 | | 22 | | | |
| 13 and over | | 57 | | | |
| | | 1999 | General average 5.4 days | | |

TABLE 2A

*On the proportion of normal oestrous cycles occurring in two colony groups of Albinos and in the gray-white strain of Long and Evans (Evans, '24 MS.)*

| SOURCE OF ANIMALS | NUMBER ANIMALS INVOLVED | FIRST OESTRUS. AGE IN DAYS AVERAGE AND EXTREMES | NUMBER OF CYCLES AFTER FIRST FOUR | NUMBER OF CYCLES AFTER FIRST FOUR | | PROPORTION OF SHORT (NORMAL) CYCLES |
|---|---|---|---|---|---|---|
| | | | | Short (6 days and under) | Long (7 days and over) | *per cent* |
| Albinos (Slonaker colony) | 28 | 54.1 (40–67) | 125 | 99 | 26 | 79.2 |
| Albinos (Wistar colony) | 26 | 40.9 (36–51) | 159 | 138 | 21 | 86.7 |
| Gray-White cross (Long-Evans colony) | 500 | 47.3 (32–77) | 10,000 | 8948 | 1052 | 89.5 |

Careful observations made by Long and Evans ('22) using so-called "obstetrical cages" which make possible the determination of the exact time of birth—show that 90 per cent of the gestation periods fall between 21½ and 22 days.

*Lengthening of gestation period.* King ('13) found that the gestation period in lactating albino rats is of normal length if the female is suckling five or less young and is carrying five or less young.

The gestation period may be prolonged from one to six days if an albino female, suckling five or less young, is carrying six or more young.

The period of gestation is always prolonged when a female is suckling six or more young. In these cases the number of young in the second litter seems to have less influence on the length of the gestation period than has the number of young suckled; but if both litters are very large the gestation period may be extended to 34 days.

In the specially well fed series of Greenman and Duhring ('23) the lengthening of the gestation period under these conditions was much reduced.

5. *Superfecundation and superfetation.* Superfecundation occurs occasionally in the albino rat and causes an interval of two, three or more days between the birth of different members of the litter (King, '13).

In rare instances ovulation takes place in the albino rat during pregnancy and superfetation occurs. In two cases of this kind litters have been produced at intervals of about two weeks (King, '13, pp. 388 and 389).

*Parturition.* The young tend to be born when the surrounding conditions are quiet. In many cases birth occurs at night or in the early hours of the morning. The act of parturition may extend from 15–30 minutes up to 24 hours. Naturally the size of the litter affects the time taken.

There is no separation of the pubic bones (Todd, '23) and the act of parturition does not appear to cause the female discomfort.

The placenta is eaten. The placenta probably furnishes a growth promoting substance to the milk, as shown for man by Hammett ('18).

6. *Fertility and birth weight.* In considering fertility it must always be kept in mind that the reproductive capacity of the

TABLE 3

*Schematic outline of changes in the reproductive organs of the rat during the oestrous cycle of 4 days 6 hours*

Long and Evans, '23

| STAGE | LIVING ANIMAL | HISTOLOGY OF VAGINAL MUCOSA | UTERUS | OVARY AND OVIDUCT |
|---|---|---|---|---|
| 1. (12 hours) | Vaginal mucosa, slightly dry. Smear of epithelial cells only. Lips a little swollen. In heat toward end. | Many layered (8–12) 0.08–0.1 mm. thick. Mitoses active. Cornified layer *under* superficial layer of epithelium. No leucocytes | During Stage 1 uterus becomes distended with fluid increasing in diameter from 2.3 to 3.7 mm. | Follicles large |
| 2. | Vaginal mucosa dry and lusterless. Smear of cornified cells only. Lips swollen. In heat | 7–11 layers of cells 0.08–0.1 mm. thick. Cornified layer well formed and superficial. No leucocytes. Mitoses fewer | Reaches greatest distention (5 mm.) and thinness of epithelium and then regresses to diameter of 1.8 mm. Vacuolar degeneration sometimes begins | Follicles largest. Eggs may undergo maturation |
| 3. (2 and 3 27 hours) | As in Stage 2, but cornified material abundant (cheesy) and animal not in heat | 5–9 cells thick. 0.064 mm. thick. Cornified layer loose and finally completely detached. No leucocytes. Mitoses still fewer | Diameter of uterus about 2.0 mm. Epithelium undergoing vacuolar degeneration | Ovulation. Secretion of fluid into periovarial space and oviduct |

| | | | | |
|---|---|---|---|---|
| 4.<br>(6 hours) | Vaginal mucosa slightly moist. Smear of cornified cells and leucocytes. Swelling of lips gone | 4–8 cells thick. 0.062 mm. thick. Cornified layer gone. Many leucocytes. Mitoses increasing | Diameter of uterus 2.2 mm. Some vacuolar degeneration but also regeneration. | Young corpora lutea. Eggs in oviduct. Follicles smallest |
| 5.<br>Dioestrous interval (57 hours) | Vaginal mucosa moist, glistening. Smear of leucocytes and epithelial cells. Variable amount of mucus | 4–7 cells thick. 0.042 mm. thick. Leucocytes. Mitoses not numerous | Diameter 1.7 mm. Epithelium undergoing regeneration | Follicles of various sizes. Corpora lutea continue to grow. Eggs traversing oviduct throughout early interval |

female is a very sensitive reaction which may be stimulated or depressed by a variety of conditions—and for this reason a rather wide range of results is to be anticipated.

At the beginning of ovulation Sobotta and Burckhard ('10) find on the average a total of thirteen ova in both fallopian tubes. In their series, Long and Evans ('22) found an average of 9.6 ova in both tubes. The largest litter we have noted in the common Albino contained eighteen. Several such litters have appeared.

The number of ova found in the oviducts is only about 90 per cent of the number of corpora lutea formed, (Long and Evans '22). Moreover, these observers found that the average size of the litters was 6.9, so that about one-third of the ova formed (9.6) failed to produce young. When, therefore, the number of young born is considered, the foregoing relations should be held in mind. The majority of albino females do not produce more than four or five litters, although occasional animals may produce three times as many.

TABLE 4

*Table showing length in hours of the component parts of the oestrous cycle of the rat*

| STAGE | MODE | AVERAGE |
|---|---|---|
| | *hours* | *hours* |
| One | 12 | 14.2 |
| Two and Three | 27 | 38.0 |
| Four | 6 | 7.8 |
| Five (Dioestrous) | 48 | 53.0 |

*Size of litters.* The usual size of the litters is indicated in table 5.

It should be noted that generally these determinations have been based on the first five litters and do not extend through the possible breeding period of the female.

The litter size does not appear to be influenced by season, (King and Stotsenburg '15). It may depend however on the position of the litter in the litter series as can be seen from table 6.

In this instance the litter size is determined for the entire breeding period and is therefore low, 6.1, as compared with the values in table 5 (King '24).

Table 6 shows that the second litter is the largest, and this agrees with common experience. Table 6 shows also the first nine litters to be of good size, but the number of young in the later litters is small. In table 6 the marked decline in litter size comes at the tenth litter where the number of young drops to 4.4, the average that is maintained until the end of the series. This means that the size of the litter after the second tends to diminish with the age of the mother. Whether this is due to

TABLE 5

*Showing the average size of litters for the earlier portion of the breeding period*

| AUTHORS | NUMBER OF LITTERS | NUMBER OF YOUNG | AVERAGE SIZE OF LITTER | SEX RATIO, NUMBER OF MALES PER 100 FEMALES |
|---|---|---|---|---|
| Crampe ('84) | 394 | 2503 | 6.3 | 105.6 |
| King and Stotsenburg ('15) | 1089 | 7619 | 7.0 | 107.5 |
| Long and Evans ('22) | 625 | 4313 | 6.9 | — |

TABLE 6

*Data for entire series of litters cast by 148 stock albino females (King '24)*

| LITTER SERIES | NUMBER OF LITTERS | NUMBER OF INDIVIDUALS | AVERAGE NUMBER OF YOUNG PER LITTER | MALES | FEMALES | NUMBER OF MALES TO 100 FEMALES |
|---|---|---|---|---|---|---|
| 1 | 148 | 903 | 6.1 | 462 | 441 | 104.7 ± 4.70 |
| 2 | 148 | 992 | 6.7 | 498 | 494 | 100.8 ± 4.32 |
| 3 | 142 | 876 | 6.1 | 454 | 422 | 107.5 ± 4.88 |
| 4 | 128 | 824 | 6.4 | 402 | 422 | 95.2 ± 4.45 |
| 5 | 98 | 547 | 5.5 | 279 | 268 | 104.0 ± 5.99 |
| 6 | 64 | 344 | 6.4 | 184 | 160 | 115.0 ± 8.38 |
| 7 | 38 | 228 | 6.0 | 128 | 100 | 128.0 ± 11.37 |
| 8 | 23 | 137 | 5.9 | 72 | 65 | 110.7 ± 12.64 |
| 9 | 13 | 85 | 6.5 | 51 | 34 | 150.0 ± 22.39 |
| 10 | 5 | 22 | 4.4 | 13 | 9 | |
| 11 | 3 | 12 | 4.0 | 5 | 7 | |
| 12 | 3 | 13 | 4.3 | 8 | 5 | |
| 13 | 2 | 9 | 4.5 | 3 | 6 | |
| 1–13 | 815 | 4992 | 6.1 | 2559 | 2433 | 105.2 ± 2.00 |

age, pure and simple, or depends on the bearing of previous litters has not been determined.

In extracted Albinos and in Norways the litter size is close to that for the stock Albinos, while in extracted Norways and in Piebalds it is somewhat higher: 6.7 and 6.8 respectively (King, '24).

Greenman and Duhring ('23) find however in their exercised and particularly well fed series, breeding at four months, the first litter to be the largest. This is possibly another instance of precocity which may be thus induced, or it may be the result of the later age at which the female bred.

*Mortality.* From a study covering five years and based on the litters from 415 rats, King ('21) determined that 1.3 per cent of the young were still born. The still born males were markedly in excess of the females (129 males to 100 females) due apparently to a greater intrinsic weakness of the male fetus.

Young are also lost during the early days of lactation, through injury or neglect. Only a small number are born dead in the case of normal mothers. Where abnormal conditions exist, the number of dead born may be high.

*Birth weight.* The birth weights as determined by King ('15) are shown in table 7 according to the increasing age of the mother and in table 8 according to the increasing body weight of the mother.

On the average the birth weight of the males exceeds by 0.3 grams that of the females.

King ('15) reaches the following conclusions: Increasing age or increasing weight of the mother (the two being correlated) give a heavier birth weight, while the increase in the number in a litter tends to diminish the individual birth weight. There is to be observed also a diminution in birth weight in those litters born of mothers below the standard size, or suffering from infectious disease.

Precise data for the birth weight require great care to secure the selection of young which have *not* suckled. This is most readily made by the use of the so-called obstetrical cage, described by Long and Evans ('22), by which the young are automatically separated from the mother at birth. Rats so obtained are strictly new-born, while most rats designated as new-born have suckled, as indicated by a white patch marking the stomach.

As the result of feeding unbalanced rations to rats Zuntz ('19) concludes that both the number of litters and the number in the litter are reduced, but that the young which are born tend to have both normal body weight and normal composition.

TABLE 7

*Showing the birth weight data for 85 litters of stock and inbred albino rats arranged according to the age of the mothers at the time that liters were cast*

| AGE OF MOTHER | NUMBER OF LITTERS | NUMBER OF INDIVIDUALS | MALES | FEMALES | TOTAL WEIGHT OF MALES IN GRAMS | TOTAL WEIGHT OF FEMALES IN GRAMS | AVERAGE WEIGHT OF MALES IN GRAMS | AVERAGE WEIGHT OF FEMALES IN GRAMS |
|---|---|---|---|---|---|---|---|---|
| (1) From 90 to 120 days... | 27 | 232 | 112 | 120 | 494.9 | 494.6 | 4.41 | 4.12 |
| (2) From 120 to 180 days... | 36 | 326 | 155 | 171 | 712.1 | 736.9 | 4.59 | 4.30 |
| (3) From 180 to 330 days... | 17 | 143 | 70 | 73 | 318.5 | 321.5 | 4.55 | 4.40 |
| (4) From 300 to 450 days... | 5 | 38 | 21 | 17 | 99.2 | 73.3 | 4.71 | 4.31 |

TABLE 8

*Showing the birth weight data for stock and inbred albino rats arranged according to the body weight of the mothers at the time that the litters were cast*

| BODY WEIGHT OF FEMALES | NUMBER OF LITTERS | NUMBER OF INDIVIDUALS | MALES | FEMALES | TOTAL WEIGHT OF MALES IN GRAMS | TOTAL WEIGHT OF FEMALES IN GRAMS | AVERAGE WEIGHT OF MALES IN GRAMS | AVERAGE WEIGHT OF FEMALES IN GRAMS |
|---|---|---|---|---|---|---|---|---|
| To 175 grams............. | 27 | 209 | 98 | 111 | 423.8 | 440.7 | 4.46 | 3.86 |
| 175 to 200 grams.......... | 23 | 222 | 108 | 114 | 491.3 | 506.8 | 4.55 | 4.47 |
| 200 to 220 grams.......... | 25 | 233 | 111 | 122 | 508.7 | 524.7 | 4.58 | 4.30 |
| 220 + grams.............. | 10 | 75 | 41 | 34 | 201.7 | 158.0 | 4.91 | 4.64 |

7. *Sex ratio.* At the two periods of greatest reproductive activity—in the spring (March–May) and again in the autumn (September–November) the proportion of males (the sex ratio) is low.

In the first litters of young females the sex ratio tends to be higher than in the later litters—but no relation of sex ratio to size of litter has been found (King and Stotsenburg, '15).

Cuénot ('99) reports a sex ratio of 105.6, while King and Stotsenburg ('15) report 107.5—without regard to the number of the litter. This ratio is however subject to a seasonal variation. There is also a relation to the litter number as shown in table 6 (King '24).

The data in table 6 show that the sex ratio for one litter group bears, seemingly, no relation to the ratio for the group immediately preceding or following, and the differences between successive ratios, when judged by their probable error, are of little import. The ratios seem, however, to indicate that the number of males tends to increase as the litter series advances up to the ninth litter. Beyond this point the relative number of males decreases sharply, as the data for the last four litters of the series, when combined, give a sex ratio of only 107.4 males to 100 females.

For the total of 4992 albino young recorded in table 6, the sex ratio is 105.2 males to 100 females. This ratio is slightly less than that given by Cuénot, and may, perhaps, serve as a norm for sex ratio in the albino strain until a larger and more complete series of data is available.

It is to be noted that the sex ratio may vary according to strain and that within the same strain it is also subject to wide modification by selection (King, '18).

Thus in the first twenty-five generations of inbred Albinos, the first and second litters combined gave in series A a sex ratio of 121.3, while in series B the sex ratio was 85.1. These two series were from the same strain, but had been selected for the high or low sex ratio respectively (King, '18).

8. *Recognition of sex.* The recognition of sex through external characters in the young rat has been studied by Jackson ('12). He finds the male may be recognized by (1) The larger size of the genital papilla; (2) the greater anogenital distance (see table 9); (3) the absence of clearly marked nipples. (This test is applicable only up to the age of 16 days, i.e., before the

development of hair on the ventral surface); (4) small extent of the bare area just ventral to the anus (test applicable only after the 16th day).

The following is a condensed form of Jackson's table for the anogenital distance.

As a rule the descent of the testes occurs about the fortieth day of age or somewhat earlier.

9. *Body weight according to sex.* While the average weight of the females at birth is less than that of the males, yet within a few days after birth the females tend to grow more rapidly than the males and may continue so to do during the following thirty to forty days. Sometimes this leads to absolutely heavier females as shown in table 157 and table 185 (King '23) for the Norway rat. This relation appears to come about as a response to less favorable conditions which tend to retard the growth of the male more than that of the female. Under more favorable conditions the female still grows somewhat faster than the male during this period without however attaining or surpassing the body weight of the male.

TABLE 9

*Ano-genital distance in young albino rats of various ages*

| AGE | NUMBER OF EACH SEX | | AVERAGE GROSS BODY WEIGHT | | AVERAGE ANO-GENITAL DISTANCE | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| | | | *grams* | *grams* | *grams* | *grams* |
| New born...... | 10 | 12 | 5.7 | 5.4 | 2.8 | 1.2 |
| 7 days......... | 17 | 26 | 11.0 | 10.4 | 5.2 | 2.7 |
| 14 days........ | 13 | 15 | 19.5 | 18.2 | 8.2 | 4.9 |
| 20 days........ | 19 | 26 | 27.4 | 27.4 | 12.0 | 7.0 |
| 42–50 days..... | 19 | 13 | 73.3 | 71.0 | 21.0 | 13.0 |

At 100 days of age the males weigh about 12 per cent more than the females and this difference in body weight tends to increase with advancing age, up to 18 per cent or more. The sex difference is always found, but the amount of difference varies according to the strain and other conditions.

*Maximum weights.* In 1915 the maximum weights reported were male 438 grams (fat); female 359 grams (fat). In The

Institute colony a considerable number of rats of both sexes surpass these weights to-day. Moreover, exceptional rats of large size are now appearing. A male of 615 grams has been reared by Osborne and Mendel (MS.) and Ibsen ('21) reports one of 745 grams.

In the Institute colony several males over 600 grams have been raised. These results indicate a progressive reponse of the Albino to domestication and reflect also the influence of better food and care through a series of generations. Wild Norways of such body weights have not been recorded.

*Minimum weights.* Individuals under weight at birth tend to remain under weight during later growth (Dunn, '08). Under usual conditions "runts" are rare among rats, but in these the weight of the brain and of the spinal cord is low (King, '16).

10. *Behavior. Under natural conditions.* When wild Norways are confined in a wooden cage they almost always gnaw the boards of which it is made. This the domesticated Albinos do not do. When put in a tank of water the Albino rat swims. Often when unable to climb out over the side, it will dive and search for a way out below. This must be a reaction, for many generations unexercised.

Greenman and Duhring ('23) have specially described the clicking of the teeth—a sign of content—and other behavior of the gentle rats—when these are taken in the hand. They have also described the nest building of the pregnant female and the behavior of the associated male when the pair are kept in the same cage after the birth of the litter. There is no justification for the common statement that the male kills the young. When the young are killed it is the female which is usually responsible. Such rats are designated "killer" females—Stotsenburg ('23)—and these individuals often have rather definite periods for killing. The cause of this habit has not been determined, but the ovaries of these animals are of normal size (Stotsenburg, '23) so that the explanation must be sought elsewhere.

The killing is usually accomplished by a bite severing the vessels in the neck. In well tamed rats the killing of the suckling young occurs only rarely.

*Sounds.* The sounds made by the rat range from an intimate clucking used by mothers with young to small squeaks—in response to slight discomfort—rising to a high pitched scream when suffering severe pain or in great terror. Broadly speaking this last response comes most often from the wild Norways just after capture.

*Under experimental conditions.* See References.

*Activity and exercise.* When fed at midday Albinos divide the 24 hours into about 14 hours of interrupted rest and sleep and 10 hours of marked activity—from the early evening to the early morning (Szymanski, '18 a).

They are as responsive to training during the period of inactivity as during the active period (Szymanski, '18). As incentives to learning, hunger, pain, and sometimes the maternal instinct (return to the young) are effective (Szymanski, '18 b).

Richter ('22) has determined that the minor periods of activity are related to hunger, as expressed by contractions of the stomach, and Wang ('23) has found that in the female in the revolving wheel the performance—as measured by miles run—is periodic and related to the phases of the oestrous cycle (see pp. 23 and 24).

*Effects of alcohol and drugs.* See References.

*Effects of lesions of the brain and sense organs.* See References.

*Care of rats.* Greenman and Duhring ('23).

11. *Comparison with man.* When compared with man the rat shows a series of similarities which are of significance for its use as an experimental animal.

*Similarities in form relations.* The males are usually larger and heavier than the females. The females are somewhat fatter.

*The determination of the equivalent ages.* The Albino doubles its birth weight in about six days, thus in one-thirtieth the time taken by man. If a rat at three years (it is then very old) is taken as equivalent to man at ninety years, we again have a relation of 1–30 in the equivalent ages. It is assumed therefore that the rat lives thirty times as fast as man. Thus one day of rat life is equivalent to 30 days of human life (one month). When the increase in the weight of the brain, and the change in the percentage of water in the brain is determined for the two forms at the equivalent ages, these two growth changes are found to be nearly the same in both—Donaldson ('18).

For the determination of equivalence in age among mammals Brody and Ragsdale ('22) have used the three cycles of growth—termed respectively the infantile, juvenile and adolescent cycles and have taken conception rather than birth as the point of departure. When by this method the conceptional age of the maximum of the third (adolescent) cycle is multiplied by the constant 13, it gives 36.5 months, or approximately three years as the span of life for the rat. This is in good agreement with our determinations as just given. The procedure does not yield satisfactory results in the case of man.

The menopause occurs at 15–18 months, which is equivalent to 38–45 years.

*Functional similarities.* Like man the rat is omnivorous and capable of adapting itself to a wide range of diets.

*Rate of response.* Owing to the fact that the rat is living thirty times as fast as man, its responses to all the changes in its environment are relatively very rapid. To food, drugs, and alterations in external conditions, it reacts with remarkable promptness—and while this is very favorable for some sorts of study, it makes it difficult to maintain the animal in a constant condition for any considerable length of time.

## BIOLOGY : REFERENCES

*Life history.* Donaldson, '06. King, '13, '24. Kirkham, '10. Kirkham and Burr, '13. Lane, '17. Namiye, '09. Slonaker, '07, '12. Stewart, 1898. Wada, '23. Watson, '03. Wang, '23.

*Span of life.* Brody and Ragsdale, '22. Donaldson, '06. Mitchell, '11. Slonaker, '12, '12 a.

*Puberty, ovulation, oestrous cycle and menopause.* Greenman and Duhring, '23. Kirkham, '10. Kirkham and Burr, '13. Long and Evans, '22. Sobotta and Burckhard, '10.

*Period of gestation.* Long and Evans, '22.

*Lengthening of gestation period.* Greenman and Duhring, '23. King, '13.

*Superfecundation and superfetation.* King, '13.

*Parturition.* Hammett, '18. Todd, '23.

*Fertility.* Crampe, '84. Evans and Bishop, '23 a. Greenman and Duhring, '23. King, '15, '24. King and Stotsenburg, '15. Kolazy, 1871. Lloyd, '09 a.

Long and Evans, '22. Pearson, '10. Sobotta and Burckhard, '10. Watson, '06 a. Zuntz, '19.

*Mortality at birth and during gestation.* King, '21. Slonaker and Card, '23.

*Birth weight.* King, '15. Long and Evans, '22. Zuntz, '19.

*Sex ratio.* Cuénot, 1899. King, '11 a, '11 b. King and Stotsenburg, '15. King, '18, '21, '24. White, '14.

*Recognition of sex.* Jackson, '12.

*Body weight according to sex.* Dunn, '08. Ibsen, '21. King and Stotsenburg, '15. King, '16.

*Behavior. a) Under natural conditions.* Advisory Committee, '12. Bechstein, 1801. Bell, 1837–1874. Buckland, 1859. Buffon, 1749–1789. Dehne, 1855. Fischer, 1872. Greenman and Duhring, '23. Griffith, '19. Hammett, '21 g. Henneberg, '09. Hewett, '04. Kolazy, 1871. Kunkel, '19. Lambert, '10. Lantz, '10. Manouvrier, '05. Nicholls, '22. Small, 1899. Stone, '22. Stotsenburg, '23. Szymanski, '18 a. Utsurikawa, '17. Vincent and Cameron, '20. Yerkes, '16. *b) Under experimental conditions.* Allen, '04. Barber, '15. Basset, '14. Berry, '06. Brockbank, '19. Burtt, '16. Carr and Watson, '08. Carr, '17, '17 a, '17 d. Cesana, '10. Dashiell, '20, '20 a. De Camp, '20. Dodson, '17. Glaser, '10. Griffith, '20, '21. Hamilton, '16. Heron, '22. Hubbert, '14, '15, '15 a. Hubbert and Lashley, '17. Hunter, '12, '13, '15. Hunter and Yarbrough, '17. Hunter, '18, '20, '22. Lashley, '12, '17, '18. Macht and Mora, '20. Macht and Finesilver, '22. Macht and Ulrich, '22. Macht and Teagarden, '23. Moore, '21. Pechstein, '21. Peterson, '17, '17 a. Reeves, '17. Richardson, '09. Richter, '22. Ruger and Ruger, '17. Ruger, '18. Simmons, '24. Small, '00, '01. Spencer, '23. Stone, '23. Szymanski, '14, '18 b, '18 c. Ulrich, '13, '20, '20 a. Vincent, '12, '13, '15, '15 a, '15 b, '15 c. Warden, '23. Watson, '03, '07, '14, '17. Watson and Watson, '13. Wiltbank, '19. Wylie, '19. Yarbough, '21.

*Activity and exercise.* Richter, '22. Slonaker, '12. Szymanski, '18, '18 a, '18 b, '19. Wang, '23.

*Alcohol and drugs.* Arlitt, '19. Lashley, '17 a. MacDowell and Vicari, '17, '21. MacDowell, '19, '21, '22, '22 a, '22 b, '23. Macht and Bloom, '20, '21. Macht and Mora, '20 a. Macht, Bloom and Ting, '21. Macht and Ting, '22.

*Lesions of brain and sense organs.* Adams, '13. Carr, '17 b, '17 c. Franz and Lashley, '17. Lashley and Franz, '17. Lashley, '20 '21, '21 a, '22. Pearce, '17.

*Care of rats.* Greenman and Duhring, '23. Hartwell, Mottram and Mottram, '23.

*Equivalent ages.* Brody and Ragsdale, '22. Donaldson, '08, '18.

# CHAPTER 2

# GENETICS

1. General. 2. Inbreeding. 3. Coat color. 4. Inheritance: (a) Brain weight; (b) Suprarenal weight; (c) Body weight; (d) Mutations.

1. *General.* See References.

2. *Inbreeding.* Inbreeding of albino rats from males and females of the same litter, accompanied by the selection of the most vigorous litters, has been carried on for 50 generations by Dr. King. If we allow for man $3\frac{1}{3}$ generations to a century, then this is equivalent to what has occurred in man since the year 423 A. D. Using the data for the first 25 generations, King has examined the effects of inbreeding on the growth and variability in body weight (King, '18, '18 a, '18 b and '19), and also the effect on fertility, constitutional vigor and on the sex ratio, comparison in all cases being made with the data for the stock rats in the colony at The Institute. It appears that although the general form of the growth curve for body weight is unmodified, and the sex differences are unaffected, yet the inbred rats (especially the males) are heavier, while the variability in body weight is less than in the stock rats. The inbred rats attain puberty earlier, live longer and have larger litters than do the stock rats with which they were compared. The sex ratio is not modified by inbreeding, but it was possible to select two groups from the inbreds in one of which the sex ratio was high and in the other low.

The general conclusion reached by King is that inbreeding in the rat, when accompanied by selection, may be practised without giving rise to any ill effects (King '23).

3. *Coat color.* Genetic studies on the Norway rat have been concerned mainly with the inheritance of coat color. The gray coat of the wild Norway is dominant in crosses between the wild gray and the Albino. The Albinos in the $F_2$ generation

appear in the proportion of one Albino to three pigmented. In the $F_2$ and in the later generations pied animals may be had and the color pattern both fixed and modified by selection (Castle, '12, '12a, and Castle and Phillips, '14).

In the spring and autumn when the hair is renewed, the color pattern of the hooded rat is often outlined in the Albino by a differential growth of the new hair.

4. *Inheritance.* (*a*) *Brain weight.* The inheritance of brain weight in the reciprocal crosses Norway × Albino has been studied by Hatai ('15). The relative brain weight in the adult domesticated albino rat is from 12–15 per cent less than in the wild Norway. The $F_1$ and $F_2$ hybrid offspring from Norway × Albino crosses possess brain weights intermediate between those for the respective parents. There is no evidence of segregation in the hybrid brain weight data and the pigmented extracted rats possess brain weights similar to those of the non-pigmented.

(*b*) *Suprarenal weight.* The inheritance of suparenal weight in the reciprocal crosses Norway × Albino has been studied by Donaldson, J. C. ('23). In the $F_1$ generation, pigmented, the weight of the suprarenals is less than in the wild gray, while in the subsequent generations, $F_2$–$F_4$, the weight in the extracted Albinos was less than in the extracted grays, but never as low as in the pure Albinos.

(*c*) *Body weight.* The inheritance of body weight has been studied by Ibsen ('22) but the results are not yet complete.

(*d*) *Mutations.* Mutants studied at The Institute since 1906 are ruby-eyed dilute grays: a color variety of the Norway rat that was obtained near the University of Pennsylvania in 1916 (Whiting and King, '18).

Through crossing with the albino strain, two other new color varieties of rats, fawn and sepia, were also produced.

In the colony at The Institute, Hatai obtained albino mutants from captive gray Norways (Hatai, '12), and King ('23) has obtained cream mutants, the recessive of the black eyed yellow, from a strain of blacks extracted from the Norway × Albino cross, which had bred true since 1916.

## GENETICS : REFERENCES

*General.* Castle, '11, '12, '12 a. Castle and Phillips, '14. Castle, '15, '16, '16 a, '19. Crampe, 1884. Darwin, 1883. Donaldson, '16 c, '23. Dunn, '20. Gravenhorst, 1806. Hagedoorn, '11, '14. Hagedoorn and Hagedoorn, '17, '22. Hatai, '11 a, '17 b. Ibsen, '20. Little, '17. Lloyd, '08, '09, '11. Pearson, '11. Przibram, '07. Yerkes, '13.

*Inbreeding.* Crampe, 1883. King, '18, '18 a, '18 b, '19, '23 a. Przibram, '11. Ritzema-Bos, 1894.

*Coat color.* Bateson, '03. Castle, '12, '12 a, '14, '14 a. Castle and Phillips, '14. Castle and Wright, '15, '16. Castle, '19 a, '19 b. Crampe, 1877, 1885. Doncaster, '06. Fischer, 1874. Frédéric, '07. Haacke, 1895. Hanson and Stewart, '23. Hartwell, '23. MacCurdy and Castle, '07. Morgan, '09. Mudge, '08, '08 a, '09. Whiting and King, '18. Wright, '17.

*Color pattern.* Stewart, '23.

*Inheritance of brain weight.* Hatai, '15 c.

*Inheritance of suprarenal weight.* Donaldson, J. C., '23.

*Inheritance of body weight.* Ibsen, '22.

*Mutations.* Crew, '23. Hatai, '12. King, '23. Whiting and King, '18.

*Acquired characters.* Detlefsen, '23. Griffith, '22. Hanson, '23 a. MacDowell, '24. Przibram, '10. Ritzema-Bos, 1891.

# CHAPTER 3

# ANATOMY

1. Anatomy (gross and microscopic). 2. Embryology. 3. Bones—Connective tissue. 4. Muscles. 5. Blood vessels and lymphatics. 6. Nervous system. 7. Sense organs. 8. Integument. 9. Thoracic and abdominal viscera. 10. Uro-Genital system. 11. Exocrine glands. 12. Endocrine system.

Since it is our purpose to present mainly those results that are quantitative, there will appear several divisions of this chapter marked only by references to the literature.

Further, even in those divisions for which there are some available data it happens in many cases that the presentation of them can be better given in the chapters which treat of growth, and in such instances the reader is merely referred to the latter place of presentation. These general statements apply to the subsequent chapters as well.

1. *Anatomy.* In only two instances has the rat been used as the basis for a general presentation of mammalian anatomy. These are in the books by Martin and Moale, 1884, and Goto, 1906. The remaining references are to studies which apply to portions or systems only (see classified references—at the end of the chapter).

2. *Embryology:* (*a*) *Spermatogenesis.* According to Hewer ('14):

> In the newborn animal, active mitosis is occurring in the testis, and at 3½ weeks the spermatogonia can be distinguished from the spermatocytes. No lumen begins to appear in the tubules as a rule until 7 weeks. At 8 weeks spermatids are easily distinguishable. At 9 weeks typical ripe spermatozoa are plentiful, but the fully formed epididymis contains no free spermatozoa. At 10 weeks all the tubules show active spermatogenesis: the second crop of spermatozoa is appearing, while the first crop can be seen in the epididymis.

Using rats from the Institute colony Allen ('18) finds that the first spermatocyte cells begin to differentiate between the seventh and tenth days after birth and that the first spermatozoa are ripe between the thirty-sixth and fortieth days after birth, about the time of the descent of the testes. The diploid number of chromosomes in the sperm of the albino is 37. The haploid is 19.

(*b*) *Oögenesis and fertilization.* Ovulation is simultaneous in both ovaries and there is a tendency for each ovary to discharge the same number of ova. The number of young in the litter is correlated with the number discharged during one cycle, but Long and Evans ('22) found in the series of litters (averaging 6.4 young per litter) that the young represented about two thirds of the ova discharged—thus showing, from one course or another, considerable loss.

In a series of females—isolated from the males—Arai ('20) determined the number of ova present in both ovaries—between the ages of one and 947 days. The results are given in table 10 and in chart 1.

These data show a continuous decrease in the number of ova with advancing age. The largest loss occurs before the end of the suckling period. In this series the left ovary was on the average 10 per cent heavier than the right, but the number of ova on the two sides was nearly the same—being three per cent more in the right ovary. The appearance of the first corpora lutea was most closely correlated with body length—occurring between 148 and 150 mm.—equivalent in our reference tables to a body weight of 80–85 grams and an age of 62–64 days.

The ovum, after fixation with Zenker's solution containing somewhat less than the usual proportion of acetic acid, measured 60–65 μ in diameter with a nucleus about 25 μ in diameter. (Sobotta and Burckhard '10). The authors incorrectly assume that the common Albino is a variety of Mus rattus.

For the diameter of the living unsegmented egg Kirkham and Burr ('13) give 79μ as a mean value.

For the volume of the ovum see table 12.

(*c*) *On the early stages of development.* We have the observations of Huber ('15 a). His description is as follows:

> In the albino rat the segmenting ova pass from the oviduct to the uterine horn at the end of the fourth day after insemination, probably

TABLE 10

*The relation between the age and the total number of ova, and of corpora lutea*

| AGE | BODY WEIGHT | BODY LENGTH | WEIGHT OF BOTH OVARIES | NUMBER OF OVA | | | | | NUMBER OF CORPORA LUTEA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Less than 20 µ | 20 to 40 µ | 40 to 60 µ | More than 60 µ | Total | Small | Large | Total |
| *days* | *grams* | *mm.* | *mgm.* | | | | | | | | |
| 1 | 5.5 | 47 | | 35,105 | | | | 35,105 | | | |
| 3 | 7.3 | 52 | | 27,870 | 382 | | | 28,252 | | | |
| 5 | 10.6 | 60 | | 24,608 | 978 | | | 25,586 | | | |
| 7 | 13.9 | 69 | 1.8 | 20,009 | 974 | 2 | | 20,985 | | | |
| 10 | 14.8 | 76 | 2.2 | 14,826 | 542 | 38 | | 15,406 | | | |
| 15 | 20.5 | 83 | 2.4 | 15,083 | 470 | 323 | | 15,976 | | | |
| 20 | 23.7 | 89 | 6.4 | 10,090 | 404 | 469 | 113 | 11,076 | | | |
| 26 | 30.2 | 95 | 10.8 | 9,663 | 322 | 275 | 162 | 10,422 | | | |
| 30 | 34.8 | 108 | 6.7 | 11,940 | 279 | 208 | 114 | 12,541 | | | |
| 36 | 34.9 | 105 | 5.6 | 8,711 | 152 | 124 | 62 | 9,049 | | | |
| 36 | 50.0 | 122 | 10.4 | 8,565 | 184 | 137 | 112 | 8,998 | | | |
| 41 | 58.2 | 131 | 7.4 | 11,671 | 204 | 59 | 37 | 11,971 | | | |
| 41 | 61.9 | 128 | 14.0 | 9,832 | 229 | 121 | 91 | 10,273 | | | |
| 46 | 69.5 | 142 | 14.0 | 9,935 | 156 | 115 | 60 | 10,266 | | | |
| 50 | 74.6 | 146 | 11.2 | 10,698 | 197 | 74 | 64 | 11,033 | | | |
| 50 | 75.5 | 144 | 12.9 | 9,689 | 236 | 98 | 50 | 10,073 | | | |
| 60 | 93.5 | 145 | 10.3 | 10,173 | 149 | 91 | 40 | 10,452 | | | |
| 64 | 62.7 | 132 | 7.9 | 9,669 | 189 | 106 | 66 | 10,030 | | | |
| 64 | 113.5 | 165 | 31.1 | 9,439 | 398 | 187 | 47 | 10,073 | 6 | 8 | 14 |
| 70 | 106.3 | 162 | 42.8 | 6,246 | 197 | 99 | 64 | 6,606 | 9 | 22 | 31 |
| 80 | 77.3 | 140 | 9.4 | 8,258 | 189 | 77 | 42 | 8,566 | | | |
| 80* | 107.3 | 153 | 37.4 | 4,564 | 290 | 179 | 145 | 5,268 | 26 | 13 | 39 |
| 84 | 125.0 | 165 | 22.2 | 9,406 | 177 | 85 | 52 | 9,720 | 2 | 11 | 13 |
| 95 | 98.5 | 148 | 12.2 | 10,293 | 276 | 109 | 86 | 10,764 | | | |
| 95* | 160.0 | 182 | 73.5 | 6,266 | 129 | 109 | 110 | 6,614 | 33 | 13 | 46 |
| 100 | 97.8 | 156 | 13.1 | 6,853 | 133 | 43 | 39 | 7,068 | 16 | 7 | 23 |
| 100 | 78.5 | 138 | 8.8 | 5,535 | 110 | 75 | 24 | 5,744 | | | |
| 110 | 94.3 | 147 | 18.7 | 5,100 | 176 | 75 | 41 | 5,392 | | | |
| 110 | 167.1 | 185 | 41.6 | 7,290 | 307 | 101 | 46 | 7,744 | 40 | 20 | 60 |
| 140 | 123.0 | 168 | 49.2 | 8,659 | 243 | 113 | 62 | 9,077 | 12 | 17 | 29 |
| 150 | 129.5 | 171 | 32.5 | 8,621 | 222 | 138 | 42 | 9,023 | 18 | 21 | 39 |
| 198 | 142.7 | 171 | 58.1 | 2,468 | 164 | 100 | 18 | 2,750 | 33 | 30 | 63 |
| 206* | 188.5 | 185 | 54.8 | 7,782 | 155 | 97 | 32 | 8,066 | 33 | 23 | 56 |
| 262 | 145.0 | 182 | 48.9 | 3,536 | 126 | 70 | 15 | 3,747 | 61 | 31 | 92 |
| 318 | 155.0 | 189 | 36.5 | 5,460 | 126 | 87 | 29 | 5,702 | 53 | 16 | 69 |
| 385 | 161.3 | 194 | 82.6 | 4,169 | 222 | 93 | 18 | 4,502 | 24 | 25 | 49 |
| 454 | 138.7 | 194 | 33.8 | 4,465 | 160 | 78 | 56 | 4,759 | 67 | 26 | 93 |
| 559* | 198.7 | 200 | 73.5 | 4,729 | 107 | 37 | 20 | 4,893 | 27 | 11 | 38 |
| 947 | 238.0 | 215 | 65.2 | 1,709 | 128 | 61 | 21 | 1,919 | 90 | 18 | 108 |

* Pregnant.

in the 12-cell to 16-cell stage. With the beginning of the fifth day, all of the ova are to be found in the uterine horn.

The following summary of the data gained by a study of the models of oviducts containing ova in stages from the pronuclear to 12-cell to 16-cell stages in which latter stage transit to the uterine horn occurs, is presented, to indicate rate of transit within the oviduct—table 11.

It will be observed that the ova approach the uterine end of the oviduct while in the 2-cell stage (see table 11); transit through the last portion of the oviduct, where the greater part of the segmentation occurs, being relatively slow.

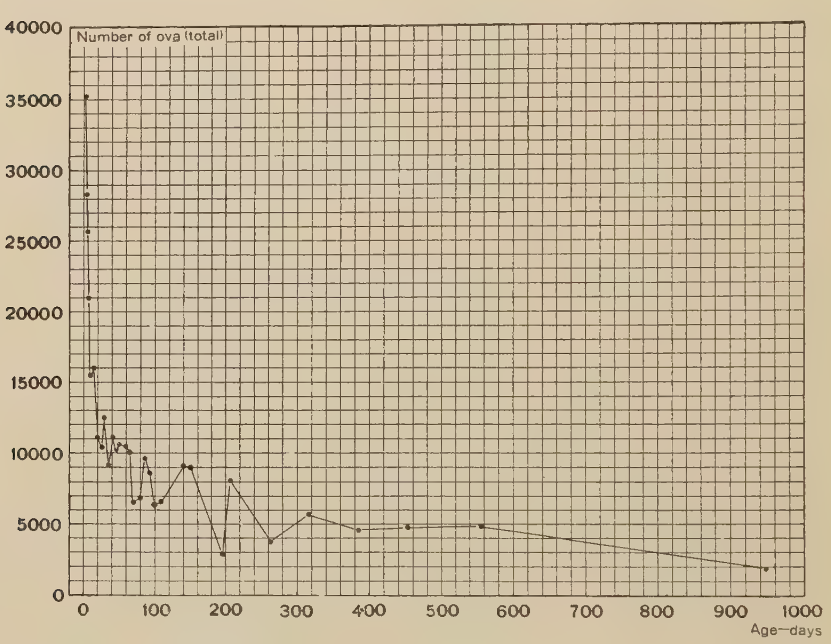

Chart 1 Showing the total number of ova in both ovaries of the albino rat at different ages.

In order to obtain the volume changes of the ova during transit through the oviduct, beginning with the pronuclear and extending to the 8-cell to 11-cell stages, reconstructions were made at a magnification of 1000 diameters, of ova presenting the stage in question. The respective volumes of these models were determined and the data reduced to the actual volumes—table 12.

The last column of table 12, giving averages, is of interest since it shows a very slight increase in the volume of the egg mass during segmentation and transit through the oviduct. Following the pronuclear stage, which, as has been seen, extends through a relatively long period and into the beginning of the second day, by which time the ova have migrated about one-fourth of the length of the oviduct, there occur only three successive mitotic divisions, including the first segmentation division, namely mitoses resulting in 2-cell, 4-cell, and 8-cell stages while the ova are in transit in the oviduct. In making this statement it is assumed that in the successive segmentations, the several cells divide synchronously, which is not in conformity with the fact. These three mitotic divisions are spaced at intervals of about 18 hours.

TABLE 11

*Showing the distance of the ova from the fimbria at various ages. Based on table 3, Huber ('15a)*

| RECORD NUMBER | SIDE RECONSTRUCTED | AGE | NUMBER OF OVA | STAGE | LENGTH OF OVIDUCT | DISTANCE OF OVA FROM FIMBRIA | RELATIVE LENGTH OF TUBE TRAVERSED |
|---|---|---|---|---|---|---|---|
| | | | | | *cm.* | *cm.* | |
| 106.......... | R. | 1 day | 8 | Pronuclear | 3.2 | 0.8 | 0.25 |
| 59.......... | R. | 2 days | 4 | 2-cell | 2.29* | 1.4 | 0.63 |
| 62.......... | L. | 2 days 22 hrs. | 5 | 2-cell | 2.45* | 2.0 | 0.84 |
| 50.......... | R. | 3 days 1 hour | 4 | 4-cell | 2.8 | 2.5 | 0.90 |
| 51.......... | L. | 4 days | 5 | 12 to 16 cell | 2.86 | 2.86 | 1.00 |

* Not the entire length of oviduct was available for reconstruction.

TABLE 12

*Volume of ova and embryos. Condensed from table 4 Huber ('15a)*

| AGE | | STAGE | AVERAGE VOLUME PER STAGE GIVEN IN CMM. |
|---|---|---|---|
| Days | Hours | | |
| 1 | 0 | Pronuclear | 0.000156 |
| 2 | 0 | 2 cell | 0.000173 |
| 3 | 1 | 4 cell | 0.000162 |
| 3 | 17 | 8 cell | 0.000184 |
| 3 | 17 | 11 cell | 0.000210 |

In the next following division, the fourth, the ovum passes from the oviduct to the uterine horn. Since the normal gestation period of the non-lactating albino rat is only 21 to 23 days, this slow rate of increase in volume and multiplication of cells during the first four days of development is of especial interest and is very probably to be accounted for by the inadequacy of the food supply of the ovum during its transit through the oviduct.

(*d*) *Later stages.* Observations have been made by Stotsenburg ('15) on the daily increase in the weight of the fetus from the 13th to the 22nd day after insemination. The data and graph are given in chapter 5, pp. 173–174.

W. Pyle '19 (MS.) reports that the giant cells—polykaryocytes—appear in the liver on the 17th day of fetal life —but by seven days after birth they have completely disappeared. In the spleen they appear at the same time as in the liver. They are abundant in the spleen during the first month after birth, diminish gradually up to 100 days, but even at later ages an occasional cell may be found.

(*e*) *Monsters.* Tailless rats. Occasionally tailless Albinos are born. The deficiency may be complete or partial. The Institute records show about one in seven thousand. Conrow ('15) has examined several of the complete cases and finds the defect in the vertebrae usually to involve the sacral vertebrae and in some cases to extend cephalad as far as the sixth lumbar. In rats surgically deprived of the tail at birth (Conrow, '17) the defect does not extend above the point of operation. Attempts to establish a strain of tailless rats have thus far failed. The congenitally tailless rats have notably heavy hypophyses.

Small-eyed rats. These appear now and then. This defect occurs in all grades and may be bilateral or unilateral. King (MS.) has obtained some evidence for the inheritance of this defect. The anatomical condition points to the early formation of the eye, followed by involutionary changes.

*Mammary glands.* There are normally six pairs, but deficiencies sometimes occur, and Stotsenburg (MS.) has noted cases where only six of the twelve nipples were present and has been able to carry a deficiency through four generations. The defect is in the system rather than in a particular pair or group of glands, and in Stotsenburg's series is most commonly represented by absence of the upper pectorals.

A six-legged rat has been described by Conrow ('17 a).

3. *Bones and connective tissue.* In table 13 is an enumeration of the bones forming the skeleton of the rat (Conrow).

TABLE 13

*List of bones*

| | | | | |
|---|---|---|---|---|
| Skull | Cranium | Nasals | | 2 |
| | | Premaxillae | | 2 |
| | | Maxillae | | 2 |
| | | Jugals | | 2 |
| | | Palatines | | 2 |
| | | Vomer | | 1 |
| | | Lachrymals | | 2 |
| | | Ethmoid | | 1 |
| | | Frontals | | 2 |
| | | Sphenoid | | 1 |
| | | Presphenoid | | 1 |
| | | Parietals | | 2 |
| | | Squamosals | | 2 |
| | | Interparietal | | 1 |
| | | Occipital | | 1 |
| | | Periotic capsules | | 2 |
| | | Tympanic bones | | 2 |
| | | Ear bones | Malleus | 2 |
| | | | Incus | 2 |
| | | | Stapes | 2 |
| | Mandible | | | 2 |
| | Teeth | | | 16 |
| Hyoid | | | | 1 |
| Vertebrae | Cervical | | | 7 |
| | Dorsal or thoracic | | | 13 |
| | Lumbar | | | 6 |
| | Sacral | | | 4 |
| | Caudal | | | (about) 30 |
| Ribs | Vertebro-sternal | | | 14 |
| | Vertebro-costal | | | 6 |
| | Vertebral | | | 6 |
| Sternum | | | | 6 |
| Shoulder girdle | Scapula | | | 2 |
| | Clavicle | | | 2 |
| Pelvic girdle | Ilium | | | 2 |
| | Ischium | | | 2 |
| | Os pubis | | | 2 |
| Humerus | | | | 2 |
| Ulna | | | | 2 |
| Radius | | | | 2 |
| Fore feet | Carpus | | | 18 |
| | Metacarpus | | | 10 |
| | Phalanges | | | 28 |
| Femur | | | | 2 |
| Tibia | | | | 2 |
| Fibula | | | | 2 |
| Sesamoid bones | Patellae | | | 2 |
| | 2 back of Femur | | | 4 |
| Hind feet | Tarsus | | | 16 |
| | Metatarsus | | | 10 |
| | Phalanges | | | 28 |
| | | | | 283 |

Nails (20) omitted

*First appearance of ossification centers.* The first appearance of ossification centers and the later bone changes have been determined by R. M. Strong (MS.) and are given in table 14.

TABLE 14

*Summary of first appearances of ossification centers and of later bone changes in the albino rat (Wistar Institute Material—R. M. Strong, MS. '23).*

| | AGE PERIOD | | | | | |
|---|---|---|---|---|---|---|
| | Prenatal | | Birth | | Postnatal | |
| | Days | Hours | Days | Hours | Days | Hours |
| *Skull:* | | | | | | |
| Mandible | 17 | 1 | | | | |
| Maxillae | 17 | 1 | | | | |
| Frontals | 17 | 1 | | | | |
| Premaxillae | 17 | 8 | | | | |
| Parietals | 17 | 8 | | | | |
| Squamosals | 17 | 8 | | | | |
| Basioccipital | 17 | 8 | | | | |
| Vomer | 17 | 8 | | | | |
| Palatines | 17 | 8 | | | | |
| Pterygoid process of Basisphenoid | 17 | 8 | | | | |
| Exoccipital | 17 | 8 | | | | |
| Lacrimals | 18 | | | | | |
| Nasals | 18 | | | | | |
| Jugals | 18 | | | | | |
| Interparietal | 18 | 10 | | | | |
| Tympanic | 18 | 10 | | | | |
| Basisphenoid | 18 | 10 | | | | |
| Alisphenoidal process of Basisphenoid | 19 | 8 | | | | |
| Presphenoid | 19 | 9 | | | | |
| Supraoccipital-paired centers | 19 | 9 | | | | |
| Alisphenoidal process united with Basisphenoid junction still distinct at | | | | | 3 | |
| Orbitosphenoidal processes of Presphenoid | | | 22 | 19 | | |
| In contact with Presphenoid | | | | | 2 | |
| *Vertebrae:* | | | | | | |
| Arches | | | | | | |
| First cervical to 2nd thoracic | 17 | 8 | | | | |
| Extended to 1st sacral | 18 | 10 | | | | |
| In all arches | | | 22 | 19 | | |

TABLE 14—*Continued*

| | AGE PERIOD | | | | | |
|---|---|---|---|---|---|---|
| | Prenatal | | Birth | | Postnatal | |
| | Days | Hours | Days | Hours | Days | Hours |
| Bodies: | | | | | | |
| Fourth thoracic to sixth lumbar | 18 | 10 | | | | |
| Extended to all thoracic and all four sacral | 19 | 10 | | | | |
| Extended to seventh cervical and fourth caudal | 21 | | | | | |
| Extended to third cervical and seventh caudal | 22 | 10 | | | | |
| Extended to first cervical with 2nd cervical doubtful | | | 22 | 19 | | |
| Extended to all cervical and to 22nd caudal vertebrae | | | | | 3 | |
| Extended to 28th caudal | | | | | 21 | |
| Sternum: | | | | | | |
| Centers I to IV | 19 | 10 | | | | |
| V to VI (posterior) | 21 | | | | | |
| Ribs: | | | | | | |
| Ribs II to XI | 17 | 1 | | | | |
| All ribs at | 18 | 10 | | | | |
| Limbs: | | | | | | |
| Clavicle | 16 | 8 | | | | |
| Humerus | 17 | 1 | | | | |
| Radius (very slight) | 17 | 1 | | | | |
| Ulna (very slight) | 17 | 1 | | | | |
| Scapula | 17 | 8 | | | | |
| Ilium | 17 | 8 | | | | |
| Femur | 17 | 8 | | | | |
| Tibia | 17 | 8 | | | | |
| Fibula | 17 | 8 | | | | |
| Pubis | 19 | 10 | | | | |
| Ischium | 19 | 10 | | | | |

TABLE 14—*Concluded*

| | AGE PERIOD | | | | | |
|---|---|---|---|---|---|---|
| | Prenatal | | Birth | | Postnatal | |
| | Days | Hours | Days | Hours | Days | Hours |
| *Carpals* all had some ossification | | | | | 8 | |
| *Metacarpals:* | | | | | | |
| Third | 18 | 10 | | | | |
| Second and fourth | 19 | 10 | | | | |
| Fifth | 21 | | | | | |
| First | | | | | 8 | |
| *Phalanges of hand:* | | | | | | |
| Terminal phalanx the first to show ossification | | | | | | |
| All phalanges except 1st of 1st digit | | | | | 3 | |
| All phalanges | | | | | 3 | |
| *Tarsals:* | | | | | | |
| Astragalus | | | | | 2 | |
| Calcaneus | | | | | 2 | |
| All others | | | | | 14 | |
| *Metatarsals:* | | | | | | |
| Third | 18 | 10 | | | | |
| Second and fourth | 19 | 10 | | | | |
| Fifth | 21 | | | | | |
| First | | | 22 | 19 | | |
| *Phalanges of foot:* Terminal phalanx of all five digits | 21 | | | | | |
| All phalanges | | | | | 3 | |

In table 14A Strong compares the fetal ages in the rat and man at which the first ossification appears. In the rat the interval between the first and last instance is 5 days and 18 hours, while in man it is 56 days. The fraction of the gestation period required by the rat is slightly greater than that required by man.

Occasionally, slight differences in time of first ossification for right and left sides were found. The individuals of a litter showed only trivial variations in the time of first ossification.

Apparently the rate, time, and order of ossification are remarkably constant in the albino rat. Though only one litter was used for each stage, comparisons of successive stages and the constancy in litters seem to warrant this statement.

TABLE 14A

*Comparative table giving time of first ossification of the skull bones in the rat and man, during fetal life. (R. M. Strong, MS., '24)*

| | RAT | MAN |
|---|---|---|
| Mandible | 17 days + 55 minutes | 39 days |
| Maxilla | 17 days + 55 minutes | 39 days |
| Frontal | 17 days + 55 minutes | 56 days |
| Squamosal | 17 days + 8¼ hours | 56 days |
| Premaxillary | 17 days + 8¼ hours | 42 days |
| Parietal | 17 days + 8¼ hours | 56 days |
| Basioccipital | 17 days + 8¼ hours | 65 days |
| Exoccipital | 17 days + 8¼ hours | 56 days |
| Vomer | 17 days + 8¼ hours | 57 days |
| Palatine | 17 days + 8¼ hours | 57 days |
| Lacrimal | 18 days | 85 days |
| Nasal | 18 days | 57 days |
| Tympanic | 18 days | 65 days |
| Basisphenoid | 18 days | 83 days |
| Interparietal | 18 days + 9½ hours | 57 days |
| Supraoccipital | 18 days + 9½ hours | 55–56 days |
| Alisphenoid | 18 days + 9½ hours | 83 days |
| Orbitosphenoid | 22 days + 19 hours | 83 days |

*Skull.* Sutures: The following bones are more or less distinctly outlined by sutures at 525 days.

Paired: Maxillae, premaxillae, nasals, palatines, frontals, parietals, jugals, petrosals, squamosals and tympanics. The angle of the nasals with the frontals becomes more marked in old rats, giving a "Roman nose" effect.

Unpaired: The interparietal, supraoccipital, basisphenoid, and presphenoid are all more or less distinct in the same specimen. The interparietal is entirely outlined. The supraoccipital is fused with the exoccipital.

The dorsal surface of the skull of very old rats tends to become roughened. This is conspicuously so at 726 days, and less so at 525 days. At three months a crest and fossa become well developed across the lateral portions of the parietals. Both are fully outlined at 40 days, but more evident at 54 days. They are most conspicuous in the skull at 726 days.

*Scapula.* There is little ossification in the acromion and spine at 40 days, and still much cartilage in the coracoid process at 40 days which is essentially fused with the scapula at 99 days.

*Pelvis.* Mature rats show a marked pectineal eminence and a preacetabular tubercle. These are recognizable at 46 days and the tubercle at 40 days. Sutural grooves are recognizable at the junctions of the ilium, pubis and ischium at 73 days, but only traces remain at 99 days.

TABLE 15

*Fusion of cartilage plates (Dawson, MS. '23)*

| BONES | AT ONE YEAR | | AT TWO YEARS | |
|---|---|---|---|---|
| | Proximal | Distal | Proximal | Distal |
| Humerus | P. | A. | P. | A. |
| Radius | A. | P. | A. | P. |
| Ulna | P. | P. | P. | P. |
| Femur | P. | P. | P. | P. |
| Tibia | P. | A. | P. | A. |

*Fusion of epiphyses of the long bones.* A. B. Dawson (manuscript, '24) has made observations on the fusion of the epiphyses in the various bones of rats one and two years of age.

His results on the limb bones are given in table 15. Cartilage plate present (P.), cartilage plate absent (A.).

It is apparent from this that these bones are still in a condition to increase in length after two years, and this is in harmony with the long continued skeletal growth as determined by direct measurements.

Additional information is given in table 15 A for the time of fusion in the bones which fuse early, and also a set of observations on bones from a rat 37 months old.

The proximal epiphysis of the ulna appears to be rather variable. Since this is an extra-articular epiphysis it will not affect total length of the forelimb. The slightly delayed fusion of both proximal and distal ends of the fibula, as compared with the tibia, may explain the decided bowing of the fibula from the tibia.

*Skull measurements.* For data on the growth of the entire skeleton see Chapter 6.

TABLE 15A

(*A. B. Dawson, MS. '24*). *Age and sequence of fusion of the epiphyses in the long bones*

| BONE | REMARKS |
|---|---|
| Humerus, distal epiphysis (capitulum and Trochlea) | Cartilage interrupted at end of first month. Fused during second month |
| Radius, proximal epiphysis | Fused during third month |
| Tibia, distal epiphysis | Fused during third month |
| Fibula, distal epiphysis | Fused during fourth month |
| Ulna, proximal epiphysis | Fused between 25–31 months |
| Femur, head | Fused at 31 months |
| Femur, distal epiphysis | Cartilage interrupted 37 months |
| Tibia, proximal epiphysis | Cartilage interrupted 37 months |
| Fibula, proximal epiphysis | Cartilage interrupted 37 months |
| Humerus, proximal epiphysis | Cartilage interrupted 37 months |
| Radius, distal epiphysis | Cartilage complete 37 months |
| Ulna, distal epiphysis | Cartilage complete 37 months |

Skull measurements have been made by Hatai ('07 c). The following description is extracted from his paper.

For this study 53 male and 51 female skulls of mature Albinos (rats more than 150 days old) were measured. These skulls had been carefully cleaned and dried at room temperature. The following measurements were made with vernier calipers: 1) the length of the entire skull; 2) the fronto-occipital length; 3) the zygomatic width; 4) the length of the nasal bone; 5) the height of the skull; 6) the width of the cranium or the squamosal distance. In every case the maximum length alone was recorded in millimeters.

The horizontal straight line joining the tip of the nasal bone to the end of the occipital bone is called the length of the entire skull. This however is not exactly equal to the sum of the length of the nasal bone and that of the fronto-occipital.

The fronto-occipital length was determined in the following way: Since the length measured with the calipers from the tip of the nasal

TABLE 16

*Giving for both sexes the mean values for several measurements in millimeters on the cranium, together with the standard deviation and the coefficient of variation and the respective differences. Based on table 1. Hatai ('07 c)*

| IN MILLIMETERS | | MEAN | | STANDARD DEVIATION | | COEFFICIENT OF VARIATION | | NUMBER OF RATS |
|---|---|---|---|---|---|---|---|---|
| | | μ | Difference | μ | Difference | μ | Difference | |
| Length of the entire cranium | ♂ | 43.3±0.17 | 1.71±0.20 | 1.79±0.12 | 0.53±0.14 | 4.13±0.27 | 1.11±0.34 | 53 |
| | ♀ | 41.5±0.12 | 3.9% | 1.26±0.08 | | 3.02±0.20 | | 51 |
| Zygomatic width | ♂ | 21.7±0.11 | 0.82±0.14 | 1.18±0.08 | 0.30±0.06 | 5.41±0.36 | 1.23±0.45 | 53 |
| | ♀ | 20.9±0.08 | 3.8% | 0.88±0.06 | | 4.19±0.28 | | 51 |
| Length of the nasal bone | ♂ | 17.0±0.10 | 1.27±0.12 | 1.04±0.07 | 0.25±0.09 | 6.12±0.40 | 1.07±0.53 | 53 |
| | ♀ | 16.0±0.08 | 7.5% | 0.79±0.05 | | 5.05±0.34 | | 51 |
| Fronto-occipital length | ♂ | 27.3±0.09 | 0.91±0.13 | 1.01±0.07 | 0.10±0.09 | 3.69±0.24 | 0.26±0.33 | 53 |
| | ♀ | 26.4±0.09 | 3.3% | 0.90±0.06 | | 3.43±0.23 | | 51 |
| Squamosal distance | ♂ | 15.3±0.01 | 0.22±0.04 | 0.34±0.02 | | 2.21±0.15 | | 53 |
| | ♀ | 15.1±0.04 | 1.4% | 0.41±0.03 | −0.07±0.04 | 2.72±0.18 | −0.50±0.23 | 51 |
| Height of cranium | ♂ | 11.5±0.05 | 0.35±0.07 | 0.53±0.03 | 0.15±0.04 | 4.58±0.30 | 1.21±0.38 | 53 |
| | ♀ | 11.1±0.04 | 3.1% | 0.38±0.03 | | 3.37±0.23 | | 51 |
| $(L \times W \times H)^{\frac{1}{3}}$ | ♂ | 16.9±0.04 | 0.45±0.06 | 0.48±0.03 | 0.10±0.04 | 2.83±0.19 | 0.51±0.24 | 53 |
| | ♀ | 16.4±0.04 | 2.7% | 0.38±0.03 | | 2.33±0.16 | | 51 |
| Cranial capacity in grams of shot | ♂ | 10.9±0.07 | 0.53±0.10 | 0.74±0.05 | | 6.75±0.44 | | 53 |
| | ♀ | 10.4±0.07 | 4.9% | 0.74±0.05 | −0.01±0.07 | 7.17±0.48 | −0.42±0.66 | 51 |
| Body weight in grams | ♂ | 214.9±5.32 | 47.54±5.98 | 52.89±3.76 | 32.4±4.09 | 25.08±2.68 | 12.84±2.85 | 45 |
| | ♀ | 167.3±2.74 | 22.2% | 20.47±1.61 | | 12.24±0.97 | | 37 |

TABLE 17

*Showing the range of variates and rate of increase for various characters according to sex Hatai* ('07 *c*)

| | MALE | | | FEMALE | | |
|---|---|---|---|---|---|---|
| | Minimum | Mean* | Maximum | Maximum | Mean* | Minimum |
| | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| Length of the entire cranium. | 39.4 | 43.3 | 47.4 | 44.5 | 41.5 | 38.9 |
| Rate | 100 | 100 | 100 | 100 | 100 | 100 |
| Zygomatic width. | 19.6 | 21.7 | 24.8 | 23.4 | 20.9 | 18.9 |
| Rate | 49.8 | 50.2 | 52.3 | 52.5 | 50.3 | 48.5 |
| Length of the nasal bone. | 14.7 | 17.0 | 18.7 | 17.8 | 15.7 | 14.4 |
| Rate | 37.3 | 39.2 | 39.3 | 40.0 | 37.7 | 37.0 |
| Fronto-occipital length. | 24.9 | 27.3 | 28.8 | 28.2 | 26.4 | 24.9 |
| Rate | 63.2 | 63.0 | 60.7 | 63.3 | 63.5 | 64.0 |
| Squamosal distance. | 14.6 | 15.3 | 16.2 | 16.2 | 15.1 | 14.4 |
| Rate | 37.0 | 35.3 | 34.1 | 36.4 | 36.2 | 37.0 |
| Height of cranium | 10.4 | 11.5 | 13.0 | 12.2 | 11.1 | 10.3 |
| Rate | 26.4 | 26.5 | 27.4 | 27.4 | 26.8 | 26.4 |

* Taken from Table 16.

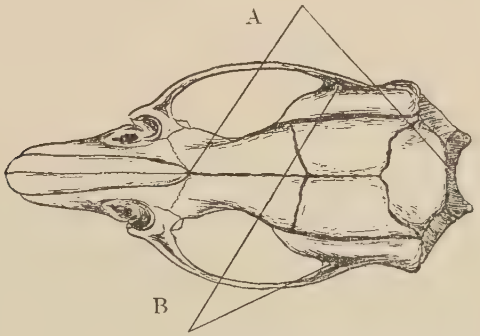

Fig. 1. *A*, Fronto-occipital length; *B*, squamosal distance.

bone to the posterior end of the inter-parietal bone is usually less than the length measured from the same point to the end of the occipital bone, both measurements were taken (see fig. 1). The difference between these two measurements was added to the length from the tip of the frontal bone to the end of the inter-parietal bone, and the sum was called the fronto-occipital length.

The width of the cranium (squamosal distance) was determined by taking the maximum distance between the two points (right and left) where the zygomatic bones rest on the lateral walls of the cranium.

The height of the skull was determined by measuring a perpendicular distance between the greatest convexity of the parietal bone in the median line and the junction line between the basi-occipital and the basisphenoidal bones on the ventral surface.

The cranial capacity: The skull was held vertically, with the nose downwards and was filled with fine shot (no. 11) to the upper level of foramen magnum and then the nose of the skull gently struck twice against the palm of the hand.

Although this is a simple procedure yet it needs the greatest care to produce uniform results. By practice Hatai has been able to reduce the difference between the first and second filling to less than one per cent. The cranial capacity thus determined in the terms of shot weight can be transformed into brain weight as follows: by dividing the weight of the shot in the case of the males by 5.980 and in the case of the females by 6.009. Tables 16 and 17.

The greatest difference found between the measurements of the skulls for the two sexes is in the nasal bones, which are nearly 2 per cent longer in the male skull. The greater relative length of the nasal bones in the male may be regarded as a secondary sexual character (Hatai).

*Teeth.* Addison and Appleton ('15) report as follows on the size and growth of the incisor teeth in the Albino.

The dental formula of the rat is

$$I\frac{1}{1}\ C\frac{0}{0}\ P\frac{0}{0}\ M\frac{3}{3}$$

There is only one set of teeth, and hence the dentition is monophyodont. The time of eruption of the various teeth extends over a period of 3½ weeks. The incisors are the first to appear, viz., at 8 to 10 days after birth. The first and second molars erupt at about the 19th and 21st days respectively, and it is after this latter period that the young animals may be weaned and are able to maintain an independent existence, as far as food is concerned. The third molars are delayed until two weeks later and do not appear until about the 35th day.

Owing to the lack of precise data, no exact comparison can be made with the eruption of the corresponding teeth in man. Nevertheless, the incisors and the first and second molars in the deciduous dentition of man do erupt at about the equivalent ages (i.e. thirty times the age in the rat) while the relation of the age of eruption of the third molar (the "wisdom tooth") to that of the second molar is similar in the rat to that found for these teeth in the permanent dentition of man.

The incisors are permanently-growing (or rootless) teeth, while the molars have a definite limited period of development and acquire roots. A wide diastema separates the incisors from the molars as may be seen by reference to figure 1 (Addison and Appleton ('15)). The incisors are strongly curved and Owen (1840–1845) has described the lower incisor as being the smaller segment of a larger circle, and the upper incisor as the larger segment of a smaller circle (verified by Hammett and Justice '23).

The lower incisor of a five months animal forms a segment of about four-fifths of a semicircle (140–145°).

The times of the early stages of development of the incisors were as follows:

14 day fetus—slight thickening of oral epithelium.
15 day fetus—distinct thickening and growth inwards of oral epithelium.
16 day fetus—dental ledge and beginning of flask-shaped enamel organ.
17 day fetus—dental papilla with crescentic enamel organ capping it.
19 day fetus—both ameloblasts and odontoblasts differentiated.
New-born animal—enamel and dentine formation begun.
8 to 10 days—eruption of the tooth.

At birth there are blood-vessels in the enamel organ of the molar teeth (Addison and Appleton '22).

The rate at which the teeth increase in length during their formative period and prior to attrition is given in table 18.

TABLE 18

| | TOTAL LENGTH OF INCISORS | |
|---|---|---|
| | Upper | Lower |
| | *mm.* | *mm.* |
| 1 day old | 2.3 | 3 |
| 4 days old | 3.6 | 5 |
| 7 days old | 5 | 7–8 |
| 10 days old | 7 | 11 |

Average growth of upper incisor 0.52 mm. and of lower incisor 0.88 mm. per day.

In rats at about 30 days of age the *extrusive* growth of the superior incisor teeth amounts to about 1.9 mm. per week; of the inferior incisor teeth, to about 2.3 mm. per week. The *curvative* growth of the superior incisor teeth amounts to about 1.0 mm. per week; of the inferior incisor teeth, to about 1.6 mm. per week (Marshall '21).

Throughout life growth continues, and in the adult animal is on the average 2.2 mm. per week in the upper and 2.8 mm. per week in the lower incisor.

In a five months animal the thickness of the enamel and its constituent layers measured in the mid-line of the teeth is given in table 19.

TABLE 19

| AGE: FIVE MONTHS | INCISORS | |
|---|---|---|
| | Upper | Lower |
| | μ | μ |
| Total thickness | 100–110 | 140–150 |
| Outer fibrous layer | 30–40 | 20–30 |
| Pigmented portion of outer fibrous layer | 8–10–12 | 6–8 |
| Inner plexiform layer | 70 | 120–125 |

The interstitial growth of the dentine of the persistent teeth of the rat, as shown by azo-dyes under the microscope, amounts approximately to 0.01 mm. per day (Marshall '21).

Measurements of the incisors and skulls of animals of different ages were made and are shown in table 20.

*Displacement of incisors.* Owing to various defects and accidents, one or more of the incisor teeth are sometimes displaced so that they do not wear normally. Overgrowth of the unopposed teeth follows, sometimes causing the death of the animal.

The incisor teeth are affected by parathyroidectomy (Hammett '22). After this operation they become white, opaque and fragile. Often also they overgrow as the result of displacement.

*Adipose tissue.* Representing the so-called hibernating gland, multiocular fat masses are found in the rat (Rasmussen, '23) in all of the localities where they have been described, namely: in the cervical, scapular, axillary, thoracic, renal and inguinal regions. The proportion of fat (boiling alcohol extract) has been determined by Hatai ('17) in a series from birth to maturity (see table 166).

TABLE 20

| | 23 DAYS | 41 DAYS | 10 WEEKS | 15 WEEKS | 5 MONTHS | 8 MONTHS | 10 MONTHS |
|---|---|---|---|---|---|---|---|
| | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| Naso-occipital length | 29.7 | 32.5 | 39 | 40 | 43 | 44 | 46.5 |
| Interzygomatic width* | 13.7 | 14 | 14.5 | 14.6 | 15.4 | 15.1 | 15.5 |
| Upper diastema | 7.4 | 9.5 | 10 | 11.4 | 12.3 | 12.5 | 13 |
| Upper incisor—total length | 12.8 | 15 | 18.3 | 20.3 | 23.3 | 23.7 | 26.2 |
| Upper incisor—extra-alveolar length | 5.1 | 5.5 | 7 | 8.4 | 8.7 | 9 | 9.3 |
| Lower diastema | 4.6 | 5 | 5.6 | 6 | 6.7 | 7 | 6.8 |
| Lower incisor—total length | 18.1 | 21.7 | 25.5 | 26.4 | 29.4 | 29.9 | 31.3 |
| Lower incisor—extra-alveolar length | 6.5 | 7 | 10.5 | 11.4 | 11.6 | 12 | 12.4 |

*Same as 'squamosal distance', figure 1, p. 51.

TABLE 21

| AGE | NUMBER OF MUSCLE FIBERS | NUMBER OF NUCLEI PER CUBIC MM. | AREA OF CROSS SECTION IN MM. × 37 DIAM. |
|---|---|---|---|
| Newborn | 5919 | 570645 | 552 |
| 15 days | 7252 | 357764 | 868 |
| 16 days (very well grown) | 7587 | 347343 | 1010 |
| 30 days | 7625 | 139861 | 2766 |
| 420 days | 8014 | 37542 | 11817 |

4. *Muscles.* Morpurgo ('98) has furnished data on the Musc. radialis of the albino rat; giving the number of muscle fibers and of nuclei at different ages (table 21).

5. *Blood vessels and lymphatics. Blood vessels.* Using six groups of rats, those of each group being similar in body weight, but neglecting sex, Dreyer, Ray and Walker ('12) have determined the relation of the area of the cross-section of the aorta (in mm.) to the area of the surface of the body and to the body

weight. The relation to body weight is not close, but the relation to the area of the body surface is good.

Table 22 gives the results of these determinations for body surface and shows that on the average—and neglecting signs—the mean deviation amounts to 1.18 per cent, while if signs are considered, it is but −0.27 per cent.

The formula used for computing the area of the cross section of the aorta is $A = W^{0.72}k$ where A is the area of the aorta; $W^{0.72}$ the body surface based on W the weight of the body in grams, and k a constant, peculiar to the rat and having the mean value of 21.9.

TABLE 22

*Cross section of the aorta on body area and body weight*

| GROUP | NUMBER OF RATS | AVERAGE BODY WEIGHT | AVERAGE AREA OF AORTIC CROSS SECTION | CROSS SECTION CALCULATED BY FORMULA BASED ON BODY AREA | DIFFERENCE OF CALCULATED FROM OBSERVED VALUES |
|---|---|---|---|---|---|
| | | *grams* | *sq. mm.* | *sq. mm.* | *per cent* |
| A | 3 | 36.5 | 0.610 | 0.609 | −0.16 |
| B | 4 | 53.5 | 0.793 | 0.802 | +1.12 |
| C | 5 | 81.2 | 1.07 | 1.08 | +0.93 |
| D | 6 | 129.0 | 1.50 | 1.51 | +0.66 |
| E | 7 | 166.4 | 1.83 | 1.82 | −0.55 |
| F | 2 | 296.0 | 2.85 | 2.75 | −3.64 |

*Vascularity of central nervous system.* Using one hooded rat and nine Albinos, Craigie ('20) has determined the vascularity of different parts of the nervous system. Four of these rats were from The Wistar Institute and five from Toronto. Four of the total number were females. All were mature. The nervous system was injected with carmin gelatin and the total length of the injected vessels in μ determined in a unit volume of tissue at 21 localities. There was no significant difference between the results from the Institute rats and those from Toronto.

The females however show a slightly better vascular supply—especially in the gray matter.

The mean values for total lengths in the entire series of rats are given in detail according to localities in table 1 (Craigie, '20). From this, table 23 has been formed and the values there given are those used for chart 2. The unit volume used in table 23 in $189\mu^2 \times 200\mu$.

TABLE 23

*Showing linear measurements of blood vessels in μ in different parts of the central nervous system—Standard volume* $189\mu^2 \times 200\mu$

| LOCALITY | AVERAGE PER $189\mu^2 \times 200\mu$ | PROBABLE ERROR OF AVERAGE |
|---|---|---|
| | | *per cent* |
| Fasc. cuneatus*. | 1318 | 3.2 |
| Ventral funiculus | 1413 | 2.1 |
| Lateral funiculus | 1593 | 2.6 |
| Pyramidal tract | 2501 | 2.5 |
| Fasc. long. dors. | 3041 | 3.2 |
| Subst. gelat. Rolandi | 4159 | 5.4 |
| Nuc. mot. VII | 5230 | 3.2 |
| Nuc. XII | 5732 | 3.5 |
| Nuc. mot. V | 5837 | 2.9 |
| Ventral horn; cord | 6430 | 2.7 |
| Spinal V nucleus | 6592 | 3.8 |
| Deiters' nucleus | 6677 | 2.9 |
| Molecular layer; cerebellum† | 7116 | 2.9 |
| Dorsal horn; cord | 7203 | 2.6 |
| Inferior olive | 7693 | 3.6 |
| Superior olive | 8008 | 4.0 |
| Chief sens. V nucleus | 8072 | 2.3 |
| Granule layer; cerebellum† | 8762 | 2.3 |
| Nuc. dentatus | 9089 | 2.7 |
| Chief vestib. nucleus | 9742 | 2.8 |
| Dors. cochlear nucleus | 10523 | 3.0 |

* All the measurements for parts in the spinal cord were made in the third cervical segment.

† The measurements were made in the posteroventral region of the vermis (uvula).

As these data show, the white substance is less vascular than the gray and the efferent (motor) gray less vascular than the afferent (sensory) gray.

The vascular supply of the cerebral cortex and its several layers have also been determined by Craigie ('21), at five localities and for each of the six cortical layers. The locations for the samples are shown in figure 2.

The method and material was that used for the previous study, but the unit volume in this latter instance is $100\mu^3$. Table 24 condensed from table 3 (Craigie, '21) last half, gives the length of the capillaries in $\mu$ for this unit volume. At the same time it gives the ratio of each of the values to that for the ventral

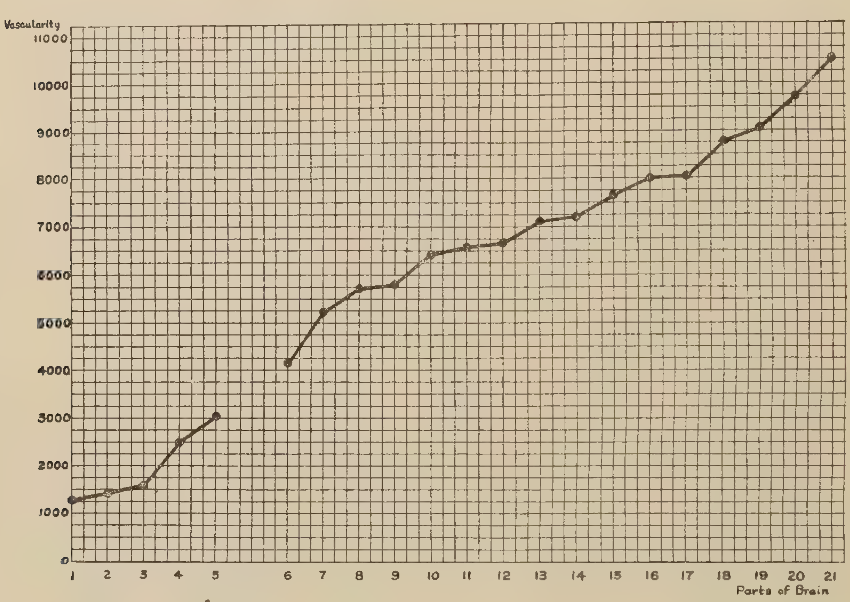

Chart 2 Graph showing the relative average vascularity in $\mu$ of the regions studied; unit volume $189\mu^2 \times 200\mu$.

*Regions*

*1*, fasciculus cuneatus
*2*, ventral funiculus
*3*, lateral funiculus
*4*, pyramidal tract
*5*, fasciculus longitudinalis dorsalis
*6*, substantia gelatinosa Rolandi
*7*, nucleus motorius VII
*8*, nucleus XII
*9*, nucleus motorius V
*10*, ventral horn; spinal cord
*11*, spinal V nucleus
*12*, nucleus of Deiters
*13*, molecular layer of cerebellar cortex
*14*, dorsal horn; spinal cord
*15*, inferior olive
*16*, superior olive
*17*, chief sensory V nucleus
*18*, granule layer of cerebellar cortex
*19*, nucleus dentatus
*20*, chief vestibular nucleus
*21*, dorsal cochlear nucleus

*Designations of areas in figure 2.*

| BRODMANN'S TERM | SUGITA'S NUMBER | DESIGNATIONS OF AREAS IN FIGURE 2 |
|---|---|---|
| Regio praecentralis | II | A |
| Regio occipitalis | IV | D |
| Regio parietalis | VII | B |
| Regio insularis | VIII | E |
| Regio temporalis | XI | C |

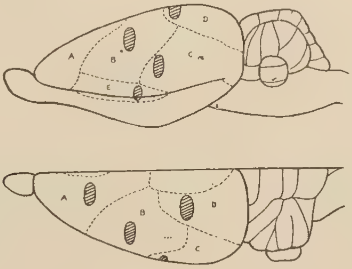

Fig. 2. Lateral and dorsal views of the left half of the brain to show the regions in which the measurements of vascularity were made. The exact location and relations of each of the areas represented is based on a comparison of figures by Fortuyn and Sugita, the names being applied in accordance with Sugita's correlation of Brodmann's terminology with these figures. Comparison with Brodmann's own figures and description seems to indicate that the anterior portion of area B is equivalent to the regio postcentralis. *A*, regio praecentralis; *B*, regio parietalis; *C*, regio temporalis; *D*, regio occipitalis; *E*, regio insularis.

TABLE 24

*Average vascularity of the five areas of the cerebral cortex in the unit volume* $100\mu^3$. *For each area the datum is the average of the five laminae. The ratio of the vascularity in each area of the cortex to that of the ventral white matter and the ventral gray matter of the spinal cord, respectively, is also entered. Based on table 3, Craigie '21*

| CORTICAL AREAS | LENGTH OF CAPILLARIES IN $\mu$ IN UNIT VOLUME | RATIO TO VASCULARITY OF | |
|---|---|---|---|
| | | Ventral white | Ventral gray |
| Insular | 3796 | 3.83 | 0.84 |
| Praecentral | 5054 | 5.11 | 1.12 |
| Occipital | 5250 | 5.30 | 1.16 |
| Temporal | 5259 | 5.31 | 1.17 |
| Parietal | 5775 | 5.83 | 1.28 |

funiculus (white matter) of the spinal cord (198$\mu$) and the ventral horn of the spinal cord (900$\mu$), both these determined for the unit volume 100$\mu^3$.

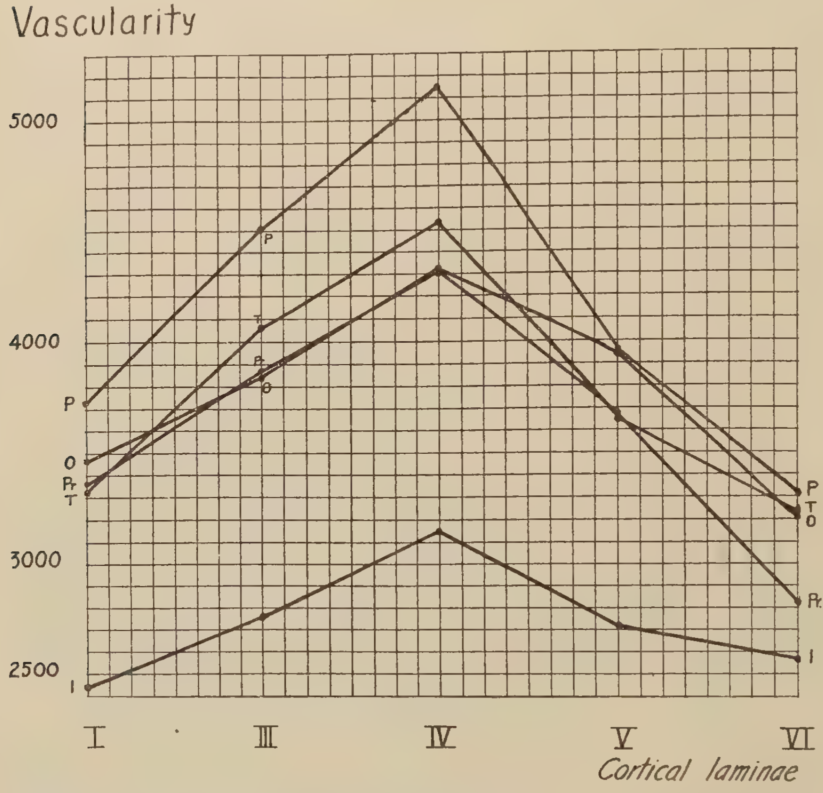

Chart 3 Showing the relative vascularity of the five cortical areas studied and of the five laminae in each. Based on table 24.

*I*, lamina zonalis
*III*, lamina pyramidalis
*IV*, lamina granularis interna
*V*, lamina ganglionaris
*VI*, lamina multiformis

*I*, insular area
*O*, occipital area
*P*, parietal area
*Pr*, praecentral area
*T*, temporal area

From these data it appears that on the average the vascular supply to the cortex is about 5.08 times that to the white matter in the ventral funiculus of the cord, and about 1.12 times that to the gray matter in the ventral horn.

The vascularity as observed for each lamina of the cortex in each area is shown in chart 3.

It is to be noted that in every area the maximum vascularity is in IV—the lamina granularis interna—and that among the areas the parietal is best supplied with blood vessels.

*Blood.* Percentage of water in the entire blood and in the serum.

The specific gravity of the blood is 1.056 (Sherrington and Copeman, 1893).

Hatai ('18) has determined the percentage of water in the entire blood of a small series of Albinos. These were from the Institute stock grown on the scrap diet and examined before the day's feeding. The rat was chloroformed, but before the heart ceased beating it was exposed in situ, the tip clipped away and the blood from it caught in a small glass weighing bottle. The fresh weight was immediately taken and after drying at 95°C. for a week the weight of the residue was obtained.

TABLE 25

*Percentage of water in entire blood of the albino rat at different ages (revised)*

| BODY WEIGHT | BODY LENGTH | AGE | SEX | PERCENTAGE OF WATER | NUMBER OF RATS |
|---|---|---|---|---|---|
| *grams* | *mm.* | *days* | | | |
| 4.2 | — | New born | Mixed | 83.0 | 8 |
| 15.5 | 77 | 15 | ♂ | 86.8 | 4 |
| 66.4 | 139 | 45 | ♂ | 81.9 | 2 |
| 103.0 | — | — | ♀ | 80.1 | 11 |
| 139.0 | — | — | ♂ | 80.1 | 8 |
| 173.8 | 192 | 108 | ♂ | 79.9 | 2 |
| 306.9 | 235 | 365 | ♂ | 79.3 | 2 |

The results are given in table 25. These percentages are in close agreement with our earlier laboratory records.

*Percentage of water in the serum.* The data from Hatai ('18 b) are given in table 27 and the graph for these in Chart 4.

*Resistance of red cells.* The resistance of the red blood corpuscles at different ages to hypotonic solutions of sodium chloride shows fairly regular changes, Takenouchi ('19) table 26.

These changes in resistance are related to the adjustment of the red blood cells, and to the water content of the serum normally surrounding them at the different ages, Hatai ('18).

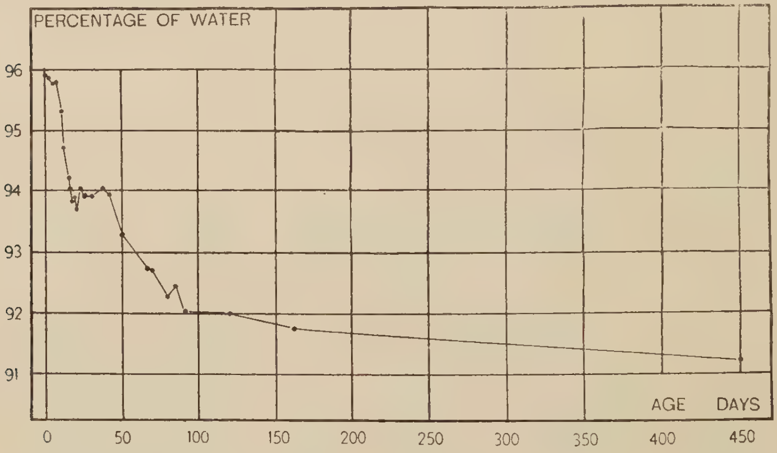

Chart 4 Showing the percentage of water in the serum of the albino rat at different ages.

TABLE 26

*Giving the concentration of the hypotonic salt solution which just produces 20 per cent hemolysis of the rat erythrocytes, based on the seven age groups*

A. Percentages according to age—Sexes combined.

B. Percentages according to age—Males and females separately, in twenty-three pairs of determinations.

| AGE | A. AVERAGE PERCENTAGES | B. AVERAGE PERCENTAGES | | |
|---|---|---|---|---|
| | Sexes combined | Number of pairs | Males | Females |
| *days* | | | | |
| 1– 25 | 0.441 | 2 | 0.425 | 0.443 |
| 25– 50 | 0.449 | 8 | 0.452 | 0.459 |
| 50– 75 | 0.457 | 5 | 0.463 | 0.463 |
| 75–100 | 0.463 | 4 | 0.458 | 0.478 |
| 100–125 | 0.449 | 2 | 0.455 | 0.465 |
| 175–200 | 0.463 | 2 | 0.434 | 0.463 |
| 225–950 | 0.470 | | | |

The concentration of hypotonic salt solution which causes approximately 20 per cent hemolysis is 0.441 per cent for the youngest and 0.470 per cent for the oldest group. As appears

TABLE 27

*Refractive index of blood serum together with percentage of water in the serum of the albino rat at different ages. 35 groups.*

| BODY WEIGHT | LENGTH | SEX | AGE | NUMBER | BLOOD SERUM | | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Water | Solids | $N_D$ | $\Delta N_D$ | |
| *gm.* | *mm.* | | *days* | | *per cent* | *per cent* | | | |
| 5.1 | | Mixed. | New born. | 8 | 95.90 | 4.10 | 1.34136 | 8.16 | Clear. |
| 7.0 | | Mixed. | 3 | 15 | 95.88 | 4.12 | 1.34132 | 8.12 | Very cloudy. |
| 8.4 | | Mixed. | 5 | 21 | 95.76 | 4.24 | 1.34261 | 9.41 | Removed from mother, clear. |
| 10.4 | | Mixed. | 7 | 15 | 95.77 | 4.23 | 1.34266 | 9.46 | Cloudy. |
| 13.8 | | Mixed. | 10 | 20 | 95.30 | 4.70 | 1.34340 | 10.20 | Removed from mother, clear. |
| 16.6 | | Mixed. | 12 | 3 | 94.71 | 5.29 | 1.34454 | 11.34 | Cloudy. |
| 18.9 | | Mixed. | 15 | 17 | 94.19 | 5.81 | 1.34509 | 11.89 | Cloudy. |
| 23.9 | | Mixed. | 17 | 9 | 94.01 | 5.99 | 1.34575 | 12.55 | Cloudy. |
| 26.9 | | Mixed. | 18 | 6 | 93.82 | 6.18 | 1.34632 | 13.12 | Cloudy. |
| 28.3 | 93 | Mixed. | 19 | 10 | 93.89 | 6.11 | 1.34579 | 12.59 | Cloudy. |
| 23.7 | | ♀ | 20 | 3 | 93.70 | 6.30 | 1.34598 | 12.78 | Cloudy. |
| 29.8 | 98 | Mixed. | 21 | 4 | | | 1.34577 | 12.57 | Cloudy. |
| 37.0 | 105 | Mixed. | 23 | 8 | 94.03 | 5.97 | 1.34549 | 12.29 | Cloudy |
| 35.9 | 108 | Mixed. | 26 | 9 | 93.92 | 6.08 | 1.34596 | 12.76 | Clear. |
| 47.2 | 115 | ♀ | 30 | 2 | 93.92 | 6.08 | 1.34568 | 12.48 | Clear. |
| 52.7 | 129 | Mixed. | 37 | 4 | 94.02 | 5.98 | 1.34581 | 12.61 | Clear. |
| 67.9 | 145 | Mixed. | 41 | 2 | 93.95 | 6.05 | 1.34619 | 12.99 | Clear. |
| 82.1 | 149 | ♂ | 44 | 1 | | | 1.34649 | 13.29 | Clear. |
| 78.9 | 148 | Mixed. | 50 | 3 | 93.27 | 6.73 | 1.34732 | 14.12 | Clear. |
| | 154 | Mixed. | 52 | 2 | | | 1.34727 | 14.07 | Clear. |
| 78.9 | 151 | ♀ | 60 | 1 | | | 1.34794 | 14.74 | Clear. |
| 94.9 | 158 | Mixed. | 66 | 6 | 92.74 | 7.26 | 1.34831 | 15.11 | Clear. |
| 109.4 | 164 | ♂ | 69 | 4 | 92.71 | 7.29 | 1.34836 | 15.16 | Clear. |
| | | Mixed. | 72 | 3 | | | 1.34868 | 15.48 | Clear. |
| | | Mixed. | 74 | 2 | | | 1.34863 | 15.43 | Clear. |
| 134.7 | 176 | Mixed. | 80 | 6 | 92.27 | 7.73 | 1.34873 | 15.53 | Clear. |
| 138.0 | 181 | Mixed. | 85 | 5 | 92.44 | 7.56 | 1.34851 | 15.31 | Clear. |
| 134.6 | 179 | Mixed. | 92 | 4 | 92.07 | 7.93 | 1.34959 | 16.39 | Clear. |
| | 192 | Mixed. | 100 | 3 | | | 1.34958 | 16.38 | Clear. |
| 176.5 | 192 | ♂ | 120 | 6 | 92.00 | 8.00 | 1.34965 | 16.45 | Clear. |
| 196.8 | 201 | ♂ | 161 | 2 | 91.75 | 8.25 | 1.35006 | 16.86 | Clear. |
| | | Mixed. | 174 | 3 | | | 1.35037 | 17.17 | Clear. |
| | | ♀ | 365 | 2 | | | 1.35123 | 18.03 | Clear. |
| 166.4 | 205 | ♀ | 450 | 2 | 91.22 | 8.78 | 1.35115 | 17.95 | Clear. |
| 250.0 | 222 | Mixed. | 597 | 2 | | | 1.35175 | 18.55 | Clear. |

in table 26 the erythrocytes of the female are less resistant than those of the male, a result which suggests that the serum of the female may contain less water than that of the male of like age.

*Refractive index of the blood serum at different ages.* The observations were made with a Pulfrich refractometer on serum obtained by centrifuging blood obtained directly from the heart. From 35 age groups the values are given in table 27 and in chart 5 (Hatai, '18 b).

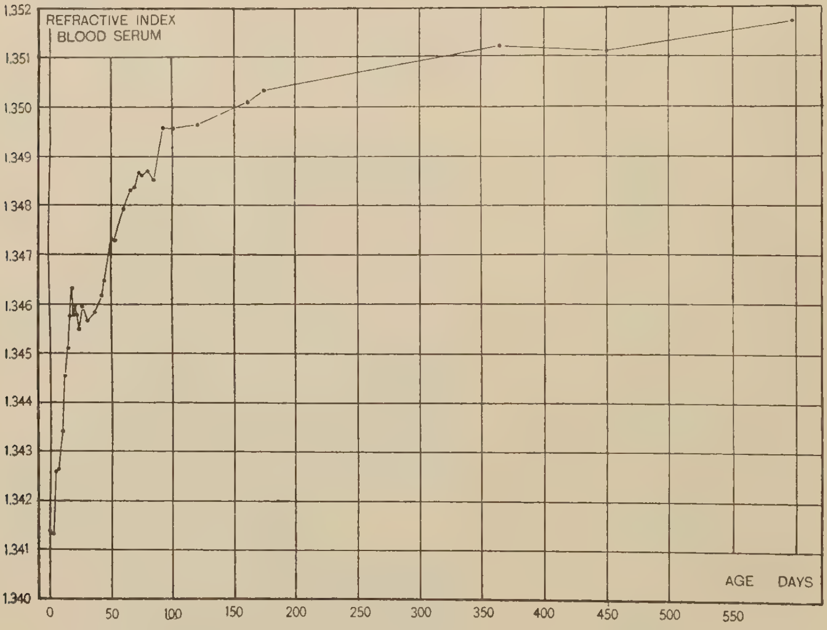

Chart 5 Showing the refractive index of blood serum at different ages.

Chart 5 shows the manner in which these values change on age. The index is slightly higher before suckling than immediately after. Three periods are recognized (1) The suckling period—to 21 days (2) From end of suckling period to puberty, at about 80 days, and (3) From puberty to the end of the record.

The percentage of water in the serum on age falls in such a manner as to give a graph which is the inverse for the increase in the refractive index—see chart 4.

Moreover when the percentage of solids in the serum is plotted on the refractive index, the relation between them is seen clearly. The refractive index, when normal, is similar in the two sexes but may be modified by fasting, defective diet, gonadectomy and disease.

Using data for the relation between the refractive index of the serum and age as determined by Hatai ('21), Hammett ('23 b) has obtained a formula (loc. cit.) which applies between the ages of 34 and 160 days and by the use of this formula the reference values for the refractive index on age as given in table 28 were obtained.

TABLE 28

*The tabulated values of the refractive index of the blood serum of the albino rat on age in days*

| AGE | $N_D$ | AGE | $N_D$ |
|---|---|---|---|
| 34 | 1.34524 | 76 | 1.34867 |
| 36 | 1.34555 | 80 | 1.34880 |
| 38 | 1.34584 | 85 | 1.34893 |
| 40 | 1.34611 | 90 | 1.34905 |
| 42 | 1.34637 | 95 | 1.34916 |
| 44 | 1.34660 | 100 | 1.34926 |
| 46 | 1.34682 | 105 | 1.34936 |
| 48 | 1.34702 | 110 | 1.34946 |
| 50 | 1.34721 | 115 | 1.34956 |
| 52 | 1.34738 | 120 | 1.34967 |
| 54 | 1.34754 | 125 | 1.34977 |
| 56 | 1.34769 | 130 | 1.34986 |
| 58 | 1.34783 | 135 | 1.34995 |
| 60 | 1.34795 | 140 | 1.35003 |
| 63 | 1.34813 | 145 | 1.35009 |
| 66 | 1.34828 | 150 | 1.35012 |
| 69 | 1.34841 | 155 | 1.35012 |
| 72 | 1.34853 | 160 | 1.35007 |

The index of refraction is a linear function of the concentration of the solute.

The percentage of water on the refractive index of the serum where $x$ is the refractive index and $y$ the percentage of water is given by the formula.

$$x = \frac{1 - 0.0012445\ y}{0.65607} \qquad (1)$$

The values for the human serum are related to those for the Albino in the following way:

(1) The absolute value of $N_D$ is the same in both forms—when mature.

(2) The refractive index is higher before suckling than it is immediately after.

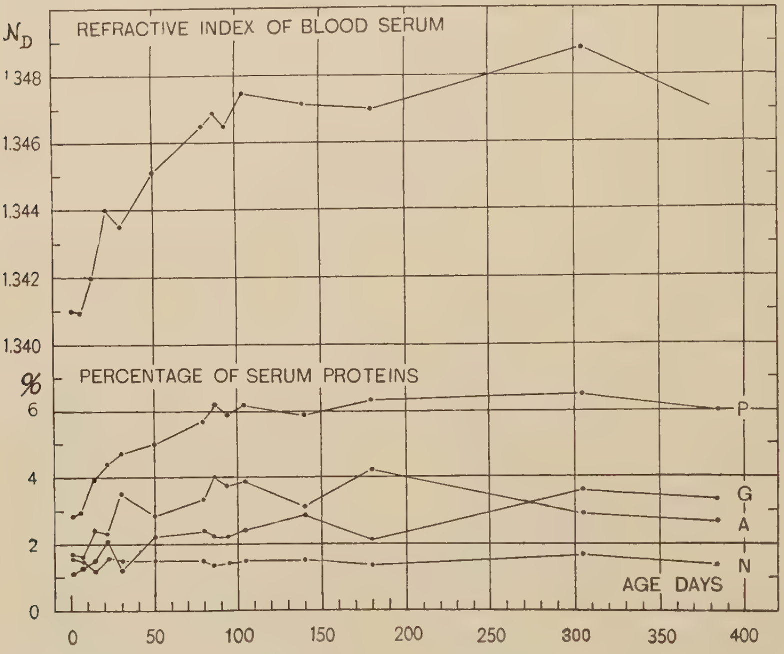

Chart 6 Changes in the refractive index and in the relative amount of serum proteins, based on the data given in table 29.

*P* = protein.
*A* = albumin.
*G* = globulin.
*N* = non-protein.

(3) After this initial fall the index increases rapidly—but from birth to puberty the values for man are higher than for the Albino.

The changes in the refractive index of the blood serum with temperature have been examined by Hammett and Teller ('22). The observations showed with rising temperature a first type (in winter rats) in which the changes in the refractive index coincided with those in the solvent water, and a second type (in spring rats) in which the changes fall away from those of the water. This indicates a participation in the second type of other serum constituents than the water. The causes of this difference are undetermined.

TABLE 29

*Changes in refractive index as well as in the proportional amount of serum proteins in albino rats at different ages*

| AGE | NUMBER OF SAMPLES ANALYZED | BODY WEIGHT (AVERAGE) | BODY LENGTH (AVERAGE) | $N_D$ | TOTAL PROTEINS | ALBUMINS | GLOBULINS | NON-PROTEIN SUBSTANCES | RELATIVE AMOUNT OF | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Albumin | Globulin |
| *days* | | *grams* | *mm.* | | *per cent* | *per cent* | *per cent* | *per cent* | | |
| Newborn. | 1 | | | 1.34101 | 2.8 | 1.7 | 1.1 | 1.6 | 60.7 | 39.3 |
| 7 | 1 | 10.8 | | 1.34095 | 2.9 | 1.6 | 1.3 | 1.5 | 55.2 | 44.8 |
| 14 | 2 | 18.3 | 82 | 1.34245 | 3.9 | 2.4 | 1.5 | 1.2 | 61.5 | 38.5 |
| 22 | 2 | 26.5 | 97 | 1.34399 | 4.4 | 2.3 | 2.1 | 1.6 | 52.3 | 47.7 |
| 30 | 5 | 24.7 | 96 | 1.34350 | 4.7 | 3.5 | 1.2 | 1.5 | 74.5 | 25.5 |
| 50 | 5 | 51.1 | 115 | 1.34508 | 5.0 | 2.8 | 2.2 | 1.5 | 56.0 | 44.0 |
| 80 | 12 | 80.8 | 144 | 1.34648 | 5.7 | 3.3 | 2.4 | 1.5 | 57.9 | 42.1 |
| 87 | 5 | 69.4 | 142 | 1.34694 | 6.2 | 4.0 | 2.2 | 1.3 | 64.5 | 35.5 |
| 94 | 7 | 76.8 | 146 | 1.34647 | 5.9 | 3.7 | 2.2 | 1.4 | 62.7 | 37.3 |
| 103 | 9 | 78.5 | 142 | 1.34745 | 6.2 | 3.8 | 2.4 | 1.5 | 61.3 | 38.7 |
| 140 | 4 | 130.8 | 171 | 1.34722 | 5.9 | 3.1 | 2.8 | 1.5 | 52.5 | 47.5 |
| 180 | 3 | 129.0 | 172 | 1.34700 | 6.3 | 4.2 | 2.1 | 1.3 | 66.7 | 33.3 |
| 305 | 6 | 177.9 | 191 | 1.34876 | 6.5 | 2.9 | 3.6 | 1.7 | 44.6 | 55.4 |
| 385 | 4 | 197.8 | 196 | 1.34699 | 6.0 | 2.7 | 3.3 | 1.4 | 45.0 | 55.0 |

To reduce the readings of the observed angle of refraction to a common base at 20°C., two formulas may be used. When the reading is made from 20°C.–35°C. then

$$I = i - 1.25\ (t - 20^\circ) \qquad (2)$$

When the reading is made from 17.5° – 20°C. then

$$I = i + 1.25\ (20^\circ - t) \qquad (3)$$

$I$ = corrected angle: $i$ = observed angle:
1.25 = minutes rise for one degree; $t$ = the observed temperature.

*Serum constitution.* Toyama ('19) has examined the serum for the relative abundance of the proteins at different ages. His results are brought together in table 29 and chart 6.

The change in total proteins follows the change in the refractive index of the serum, but after puberty the percentage of albumin falls, while that of globulin rises. The percentage of the non-protein bodies remains constant.

Corresponding results, though differing somewhat in detail, have been reported by Robertson ('20, p. 340).

Anti-pig natural hemolysin is found in the serum of rats of both sexes usually after 30–50 days of age. It appears more often in the female and especially during pregnancy and the first week after parturition. In males the number of cases tends to increase with lung infection (Suzuki, '20).

*Blood elements. Hemoglobin.* Reichert and Brown ('09) have determined that the hemoglobin crystals from the blood of the Norway rat are similar to those from the Albino, but the crystals from the blood of the house rat (M. rattus) are different.

*Weight of hemoglobin.* For the weight of hemoglobin in the entire animal, Abderhalden ('02) has reported the values given in table 30. The observations were made in September 1901—one series for the base station at Basel and the other for the elevated station at St. Moritz.

*Number.* In the adult albino rat about 7 million erythrocytes are found in blood from the heart and central vessels and 8–10 million in blood from peripheral vessels (Jolly, '06).

Jolly ('09) has given a series of determinations for the number of red cells according to age and to locality of sample—table 31.

This table 31 shows the increase in the number of erythrocytes with age and the loss in hemoglobin during the period of dependence on the mother followed by an increase later.

There is a fairly steady decrease in the "valeur globulaire" (equal to the weight of the hemoglobin divided by the number of erythrocytes) except for the period from 42–90 days—after which there is little change. The cell production in the bone marrow is in harmony with the increase in the number of erythrocytes during the first 30 days of life (Jolly 1906, p. 634).

TABLE 30

*Weight of hemoglobin in albino rat—Abderhalden ('02)*

| NUMBER | SEX | BODY WEIGHT | | WEIGHT OF HEMOGLOBIN | |
|---|---|---|---|---|---|
| | | A Entire | B Without skin and alimentary tract | Absolute | Per 1000 grams body weight B |
| | | | Basel | | |
| | | | | *grams* | *grams* |
| 1 | ♀ | 242 | 192 | 2.10 | 10.98 |
| 2 | ♀ | 192 | 160 | 1.57 | 9.78 |
| 3 | ♂ | 146 | 115 | 1.15 | 10.04 |
| 4 | ♂ | 194 | 157 | 1.56 | 9.96 |
| | | | St. Moritz | | |
| 1 | ♀ | 195 | 158 | 1.67 | 10.58 |
| 2 | ♀ | 149 | 115 | 1.28 | 11.18 |
| 3 | ♂ | 225 | 185 | 2.06 | 11.12 |
| 4 | ♂ | 195 | 159 | 1.67 | 10.48 |

TABLE 31

*Number of erythrocytes according to age and locality of sample*

| AGE IN DAYS | CENTRAL VESSELS | | | PERIPHERAL VESSELS | | |
|---|---|---|---|---|---|---|
| | Number of erythrocytes in millions | Hemoglobin (Malassez) | Valeur globulaire $\mu\mu$ grm. | Number of erythrocytes in millions | Hemoglobin (Malassez) | Valeur globulaire $\mu\mu$ grm. |
| 1 | 2.3 | 10.3 | 44.5 | 3.0 | 12.2 | 41.4 |
| 3 | 2.5 | 8.8 | 35.6 | 3.0 | 10.7 | 35.4 |
| 5 | 2.6 | 8.0 | 30.9 | 3.1 | 9.1 | 29.2 |
| 8 | 2.6 | 7.9 | 31.0 | 3.1 | 9.2 | 29.3 |
| 15 | 3.8 | 8.5 | 22.5 | 4.2 | 9.1 | 21.6 |
| 21 | 4.1 | 8.5 | 20.8 | 4.4 | 9.5 | 21.7 |
| 30 | 4.9 | 10.1 | 20.4 | 5.5 | 10.6 | 19.2 |
| 42 | 4.9 | 11.8 | 24.2 | 5.6 | 13.8 | 24.6 |
| 60 | 5.2 | 12.9 | 25.0 | 6.7 | 14.4 | 21.6 |
| 90 | 6.2 | 13.9 | 22.6 | 8.5 | 15.5 | 18.2 |
| 180 | 7.5 | 13.5 | 18.1 | 8.4 | 15.0 | 17.9 |
| 365 | 7.5 | 14.2 | 18.8 | 8.9 | 16.0 | 18.1 |
| 1095 | 7.9 | 14.8 | 18.6 | 8.8 | 16.5 | 18.8 |

A series of determinations on the increase in the number of leucocytes with age, table 32, has been made by Jolly ('19).

TABLE 32

*Changes in the number of leucocytes with age*

According to Jolly ('19) the number of leucocytes tends to increase with age

| AGE | NUMBER OF LEUCOCYTES PER MM.$^3$ | |
|---|---|---|
| | Central vessels | Peripheral vessels |
| Fetus at term | 1366 | — |
| 1 day | 2280 | 2766 |
| 8 days | 1950 | 3240 |
| 15 days | 2466 | 5666 |
| 30 days | 4900 | 7400 |
| 60 days | — | 6866 |
| 365 days | — | 10000 |

In the rat before birth the numbers of cells have been determined by Addison and Richter (MS '23). The leucocytes and erythrocytes increase from the 18 day to the 21 day stage—while the erythroblasts decrease—table 33.

TABLE 33

*Cells in 1 mm.$^3$ of prenatal blood (Addison and Richter, MS. '23). The number of cases are in parentheses*

| AGE OF FETUS | LEUCOCYTES | ERYTHROBLASTS | ERYTHROCYTES |
|---|---|---|---|
| 18 day—neck | 980 (2) | 140,000 (2) | 1,735,000 (1) |
| 19 day—neck | 1115 (2) | 38,000 (2) | 1,547,000 (5) |
| 20 day—neck | 1580 (2) | 10,250 (2) | 1,741,000 (3) |
| 21 day—tail | 1887 (2) | 4,475 (2) | 1,902,000 (5) |

TABLE 34

*Red cells and platelets of normal albino rats (condensed from Cramer, Drew and and Mottram, '22)*

| NUMBER OF CASES | WEIGHT IN GRAMS | RED CELLS IN MILLIONS | PLATELETS IN MILLIONS |
|---|---|---|---|
| 2 | 50 | 9.6 | 0.92 |
| 2 | 60 | 10.0 | 0.96 |
| 2 | 110 | 10.2 | 0.69 |
| 3 | 150 | 10.9 | 0.85 |

For the number of blood platelets in normal albino rats data are presented in table 34.

*Size.* The diameter of the erythrocytes (White, '01) is given in table 35.

In the course of development the diameter of the erythrocytes decreases up to puberty. The observations of Jolly ('23) are given in table 35 A.

TABLE 35

| FOR M. DECUMANUS | DIAMETERS IN $\mu$ |
|---|---|
| Determination by (Treadwell) | 6.5 |
| Determination by (Wormley, 1888) | 7.0 |
| Determination by (Gulliver, 1875) | 6.5 |

TABLE 35A

*Diameters of erythrocytes at successive ages up to three months*

| AGE | DIAMETER $\mu$ |
|---|---|
| 17th days of gestation | 9.7 |
| 1 day | 8.3 |
| 8 days | 8.0 |
| 15 days | 7.9 |
| 30 days | 6.7 |
| 90 days | 6.6 |

TABLE 36

*Showing the percentage and size of the various forms of the wandering cells of the blood in the rat*

| TYPE OF CELL | GRANULATION | PERCENTAGE OF TYPE | DIAMETERS IN $\mu$ |
|---|---|---|---|
| Oxyphile | Coarse | 2 | 10 |
| | Fine | 45 | 7–8 |
| Basophile | (absent) | | |
| Hyaline | | 2 | 8–10 |
| Lymphocytes | | 50 | 6 |

For the wandering cells there are data from Kanthack and Hardy ('94) tables 36 and 37.

*Blood picture.* Rivas (MS. '14) examined ten normal full grown rats using Miescher's method for the hemoglobin and Wright's stain for the cells. The blood was taken near the tip of the tail and spreads made. His results, somewhat condensed, are given in table 38.

TABLE 37

*Shows the percentage and size of various forms of the wandering cells in the peritoneal fluid of the rat, Kanthack and Hardy ('94)*

| TYPE OF CELL | GRANULATION | PERCENTAGE OF TYPE | DIAMETERS IN $\mu$ |
|---|---|---|---|
| Oxyphile | Coarse<br>Fine | 20–40<br>(absent) | 10 |
| Basophile* | Coarse<br>Fine | 5–10<br>(absent) | 18 |
| Hyaline<br>Lymphocytes | | 65–80 | 13<br>6.5 |

* Basophile cells in connective tissue 23$\mu$ in diameter.

TABLE 38

*Normal albino rat—blood picture (Rivas MS. '14)*

| HEMOGLOBIN | ERYTHROCYTES MILLIONS | NUMBER OF CASES | NUMBER OF LEUCOCYTES | P.M.N. | P.M.E. | P.M.B. | S.L. | L.L. |
|---|---|---|---|---|---|---|---|---|
| *per cent* | | | | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| 86 | 8.7 | 3 | 8,133 | 57.0 | 1.12 | 0.28 | 34.6 | 7.0 |
| 90 | 7.9 | 3 | 8,467 | 52.5 | 0.60 | 0.30 | 41.7 | 4.9 |
| 96 | 8.0 | 4 | 11,450 | 55.9 | 0.90 | 0.20 | 38.2 | 4.8 |

TABLE 39

*Normal albino rat—blood picture according to sex (Nowrey, MS. '21)*

| SEX | NUMBER OF CASES | NUMBER OF LEUCOCYTES. | P.M.N. | P.M.E. | P.M.B. | S.L. | L.L. | L.M. | TRANSITIONAL | UNCLASSIFIED |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| M. | 11 | 9281 | 62.07 | 1.54 | 0.42 | 29.55 | 2.45 | 1.83 | 0.77 | 1.37 |
| F. | 12 | 8555 | 55.71 | 4.00 | 0.45 | 30.92 | 3.56 | 2.49 | 1.20 | 1.67 |

Nowrey (MS. '21) examined for the same purpose eleven male and twelve female normal mature albino rats at The Wistar Institute.

The males were about 163 days of age and weighed 267 grams.

The females were about 165 days of age and weighed 179 grams. Table 39.

The stain used was Wilson's modification of Romanowsky's polychrome stain.

In making the classification of the cells the neutrophilic myelocytes are included with the P.M.N. group. The transitional cells are myeloid forms often grouped as large mononuclears—transitional group.

The dividing line between the small and large lymphocytes is fixed rather arbitrarily as the size of a P.M.N. The two forms are often grouped as small mononuclears. The unclassified cells are those of such morphology that it was impossible to place them, or cells so badly broken as to be unrecognizable.

In the spring of 1916 Margot, working at The Institute, examined the blood picture in 31 normal albino rats, arranged in five age groups, sexes combined. Table 40.

TABLE 40

*Normal albino rat—blood picture according to age (Margot MS. '16)*

| AGE | BODY WEIGHT | SEX | HEMOGLOBIN | NUMBER OF ERYTHROCYTES M | NUMBER OF LEUCOCYTES | P.M.N. | P.M.E. | P.M.B. | S.L. | L.L. |
|---|---|---|---|---|---|---|---|---|---|---|
| *days* | *grams* | | *per cent* | | | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| 28 | 27.5 | 5 ♂<br>6 ♀ | 82.0 | 6.5 | 7,102 | 54.6 | 0.7 | 0.04 | 34.7 | 10.0 |
| 46 | 53.6 | 3 ♂<br>3 ♀ | 90.2 | 9.7 | 10,025 | 54.5 | 1.7 | 0.00 | 34.0 | 9.8 |
| 60 | 82.2 | 2 ♂<br>4 ♀ | 98.3 | 8.8 | 9,143 | 51.7 | 0.9 | 0.01 | 41.7 | 5.7 |
| 70 | 103.1 | 2 ♂<br>3 ♀ | 83.8 | 8.8 | 8,480 | 48.2 | 1.7 | 0.00 | 41.7 | 8.4 |
| 148 | 233.0 | 3 ♂ | 103.0 | 9.4 | 9,375 | 59.0 | 0.8 | 0.00 | 33.8 | 6.3 |

The method used by Margot was as follows: For counting both the erythrocytes and leucocytes, Thomas-Zeiss apparatus was used. For dilution 0.9 per cent NaCl solution for erythrocytes and 0.2 per cent acetic acid for leucocytes were employed. For the erythrocytes 40 squares and for leucocytes the entire field were counted. The haemoglobin determinations were made with Oliver's haemoglobinometer. In some instances a modified

Sahli instrument (Newcomer's model) was also used. The differential count was made with Wright's blood stain and the percentage values based on 500 leucocytes. In making smear preparations the drop was gently spread over the slide with a cigarette paper instead of using another slide for this purpose.

The foregoing determinations by Rivas, Nowrey and Margot have all been given because they were made several years apart, were all on rats from The Wistar Institute Colony, and all on blood from the tail.

During the interval from 1914 to 1921 the colony was in a good nutritional state, though tending to improve in this respect towards the end of the period. The relation of most interest, here brought out, is that between the P.M.N. and the S.L. groups. These data are summarized in table 41.

TABLE 41

*Average number of leucocytes and percentages of polymorphonuclear cells and small lymphocytes*

| | | AVERAGE NUMBER OF LEUCOCYTES | P.M.N. | S.L. |
|---|---|---|---|---|
| | | | *per cent* | *per cent* |
| Rivas, 1914 | Total series, 10 rats | 9,350 | 55 | 38 |
| Margot, 1916 | 3 males, 148 days | 9,375 | 59 | 34 |
| Nowrey, 1921 | 11 males, 163 days | 9,281 | 62 | 30 |
| | 12 females, 165 days | 8,555 | 56 | 31 |

As table 41 shows, the relations of these two groups are similar in the three series and may therefore be regarded as applying to fertile and well grown albino rats in the Wistar colony. This point is noted because quite different values are reported for the normal albino rats from other laboratories.

Thus Kleineberger and Carl '12, Eyre '13, Cramer, Drew and Mottram '21 and Cramer (personal communication, '22) all give in normal albino rats percentage values for the small lymphocytes which are *about twice* those for the polymorphonuclear cells, while the records from The Institute up to 1921 show consistently a reverse relation. No explanation for this striking contradiction has yet been found, but as our data are from the same strain as was used for the other tables here given, these are the values presented.

It should be added that some recent observations (1924) on The Wistar Institute rats show a blood picture in agreement with the authors who find the percentage values for the small lymphocytes about twice those for the polymorphonuclear cells. It seems fair to conclude therefore at the moment that the blood picture may vary in the rat as indicated above, and yet the animals still breed well and grow vigorously. Why this wide variation comes about is a question for further investigation.

It should be noted in this connection that while both the leucocytes and erythrocytes in the rat increase in number from birth to maturity, in man the leucocytes show a great decrease and the erythrocytes a slight decrease—Addison ('24 MS.).

*Lymph nodes.* Concerning the arrangement of the lymph nodes, Job ('22) reports as follows:

There is a definite plan in the structure and arrangement of the lymph nodes in the rat.

There are two types: Type I where the nodular portion surrounds the sinusoidal portion, except at the hilus; and type II where the nodular and sinusoidal portions are lodged at opposite ends of the node.

In type I, where the nodular portion covers the whole of the node, except at the hilus, a peripheral sinus is present over the whole of the node; but in type II the peripheral sinus is present only over the nodular division.

A collateral circulation, that is, lymph vessels passing from the peripheral sinus over the surface of the node to the efferent vessels at the hilus, is a normal, constant structure in type II nodes.

Accessory nodes, which are the result of some special stimulus, are always type I in structure.

Frey's suggestion, that the sinusoidal feature of the node structure belongs more properly to the visceral areas, is further supported.

As to topographical arrangement, number and type, the lymph nodes of the rat are as constant as the other organs of the body, table 42.

6. *Nervous system.* (a) Central. (1) Brain.

Specific gravity 1.050–1.056, (Reichardt '06).

For brain weight see chapter 7, p. 206, and table 144.

For percentage of water see chapter 8, p. 308, and table 157.

For chemical composition see chapter 9, p. 320, and table 178.

TABLE 42

*Showing the number of pairs and location of the two types of lymph nodes*

| TYPES | ELBOW: KNEE CAUDAL—EACH ONE PAIR | CERVICAL PAIRS | THORACIC PAIRS | MESENTERIC PAIRS | AXILLARY PAIR | INGUINAL PAIR | LUMBAR PAIR |
|---|---|---|---|---|---|---|---|
| I | 1 | 2 | 6–12 | 6–20 | 1 | | |
| II | | 1 | | | 1 | 1 | 1 |

TABLE 43

*The number of mitoses in 13 consecutive sections, each section 6.75 $\mu$ in thickness, from the brain and spinal cord of rats at different stages of development. The fetus weighed 0.78 gms. and had a crown-rump length of 17 mm. It was probably at 17.5 days of gestation. Hamilton ('01).*

| STAGE OF DEVELOPMENT | BRAIN | |
|---|---|---|
| | Ventricular mitoses | Extra-ventricular mitoses |
| Fetus (17.5 days) | 2196 | 966 |
| Birth | 390 | 595 |
| 24 hours | 24 | 386 |
| 4 days | 115 | 443 |
| | LUMBAR CORD | |
| | Ventricular mitoses | Extra-ventricular mitoses |
| Fetus (17.5 days) | 28 | 18 |
| Birth | 8 | 45 |
| 24 hours | 1 | 13 |
| 4 days | 8 | 64 |

For vascularity see chapter 3, page 56.

*Cell division.* Cell division in the central nervous system continues after birth but soon ceases, save in the cerebellum.

The observations of Hamilton ('01) are given in table 43.

For the first 25 days after birth Allen ('12) has obtained the results given in table 44.

*Linear dimensions.* The changes in the several diameters of the fresh cerebrum with increasing brain weight have been determined by Sugita ('17).

TABLE 44

*Showing the number of mitoses per cubic millimeter of nerve tissue in the central nervous system of the stock Albino at certain levels. The figures give the number of mitoses in ten consecutive sections at each level of the cord, in five in the largest portion of the cerebellum and in five in the cerebrum in the region of the optic chiasma. The letters (a) (b) and (c) refer to different rats of the same age.*

| AGE, DAYS | CORD | | | CEREBELLUM | CEREBRUM |
|---|---|---|---|---|---|
| | Cervical | Thoracic | Lumbar | | |
| 1 | 208 | 115 | 259 | 1597 | 430 |
| 4 | 437 | 176 | 351 | 2111 | 447 |
| 6 | 446 | 236 | 320 | | 193 |
| 7 | | | | 4848 | |
| 12 | 46 | 75 | 14 | 839 | 37 |
| 20 | 00 | 00 | 00 | (c) 520 | |
| 20 | 00 | 00 | 00 | (b) 61 | (b) 27 |
| 20 | 00 | 00 | 00 | (a) 00 | (a) 18 |
| 25 | 00 | 00 | 00 | 00 | 27 |

The measurements were made with calipers along the lines indicated in figure 3 and 3 (a).

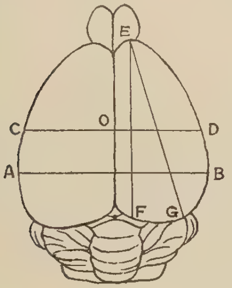

Fig. 3

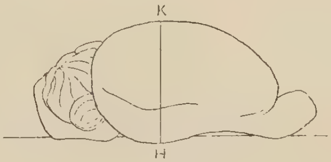

Fig. 3 a

Fig. 3. Dorsal view of the albino rat brain weighing 1.5 grams. Enlarged 1.8 diameters. To show the positions at which the two measurements for the width and the two measurements for the length were taken. AB = Width *W.B*, CD = Width *W.D*, EF = Length *L.F* and EG = Length *L.G*.

Fig. 3 a Lateral view of the albino rat brain weighing 1.5 grams. Enlarged 1.8 diameters. To show the position at which the height was measured. HK = Height *Ht*.

The values as thus obtained are given in table 45 and chart 7. These show that while the diameters in length and width increase in a similar manner, the increase in height is slow. The details of these relations are given in the original paper (loc. cit.).

TABLE 45

*Giving the brain weights for each brain weight group, the cube roots of the brain weights and the linear measurements for width, length and height of the cerebrum. Albino rat*

| BRAIN WEIGHT GROUP | NUMBER OF CASES | AVERAGE BRAIN WEIGHT | CUBE ROOT OF THE BRAIN WEIGHT | LINEAR MEASUREMENTS | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | W. B. | W. D. | L. G. | L. F. | Ht. |
| | | *grams* | | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| I | 3 | 0.161 | 0.545 | 7.02 | 6.58 | 6.18 | 5.60 | 4.52 |
| II B. | 10 | 0.254 | 0.633 | 8.64 | 8.05 | 7.12 | 6.34 | 5.39 |
| III | 11 | 0.341 | 0.699 | 9.28 | 8.52 | 7.84 | 7.20 | 5.85 |
| IV | 10 | 0.424 | 0.750 | 10.02 | 9.11 | 8.50 | 7.92 | 6.35 |
| V | 19 | 0.544 | 0.816 | 10.78 | 10.02 | 9.41 | 8.69 | 6.93 |
| VI | 4 | 0.622 | 0.854 | 11.24 | 10.44 | 10.00 | 9.39 | 7.23 |
| VII | 7 | 0.769 | 0.916 | 12.05 | 11.10 | 11.09 | 10.59 | 7.91 |
| VIII | 10 | 0.845 | 0.945 | 12.26 | 11.48 | 11.43 | 10.88 | 8.22 |
| IX | 5 | 0.954 | 0.984 | 12.90 | 12.10 | 12.12 | 11.42 | 8.54 |
| X | 6 | 1.047 | 1.016 | 13.05 | 12.22 | 12.23 | 12.03 | 8.50 |
| XI | 6 | 1.156 | 1.049 | 13.50 | 12.61 | 12.61 | 12.35 | 8.94 |
| XII | 6 | 1.253 | 1.078 | 13.79 | 12.99 | 13.04 | 12.50 | 8.93 |
| XIII | 7 | 1.334 | 1.101 | 13.87 | 13.14 | 13.45 | 13.09 | 9.16 |
| XIV | 5 | 1.449 | 1.132 | 14.04 | 13.42 | 13.77 | 13.31 | 9.25 |
| XV | 7 | 1.558 | 1.159 | 14.42 | 13.76 | 14.28 | 13.61 | 9.50 |
| XVI | 9 | 1.662 | 1.184 | 14.44 | 13.62 | 14.93 | 14.10 | 9.34 |
| XVII | 7 | 1.737 | 1.202 | 14.80 | 14.03 | 15.29 | 14.51 | 9.53 |
| XVIII | 5 | 1.832 | 1.224 | 14.88 | 14.22 | 15.47 | 14.63 | 9.68 |
| XIX | 1 | 1.924 | 1.243 | 14.65 | 14.10 | 16.00 | 15.40 | 9.75 |
| XX | 3 | 2.037 | 1.267 | 15.39 | 14.62 | 16.65 | 15.30 | 10.02 |
| Ratios II–XX..... | | 8.02 | 2.00 | 1.78 | 1.81 | 2.34 | 2.41 | 1.86 |

*The growth of the callosum.* The growth of the callosum in area has been followed by Suitsu ('20). The brains were fixed in formalin—treated with Weigert's rapid mordanting fluid, imbedded in parlodion, sectioned as near the median plane as possible and stained by the Kultschitzky-Wolters method. The calculated areas of the callosum obtained from this material are given in table 46 and in chart 8 in which the observed values are also entered.

The theoretical curve in chart 8 has been computed by formula (11). When a comparison is made between the calculated area of the brain, (Suitsu, '20, p. 354) and that of the callosum, it appears that in the Albino the area of the callosum is 3.29 per cent that of the brain area—while in man it is 4.44 per cent.

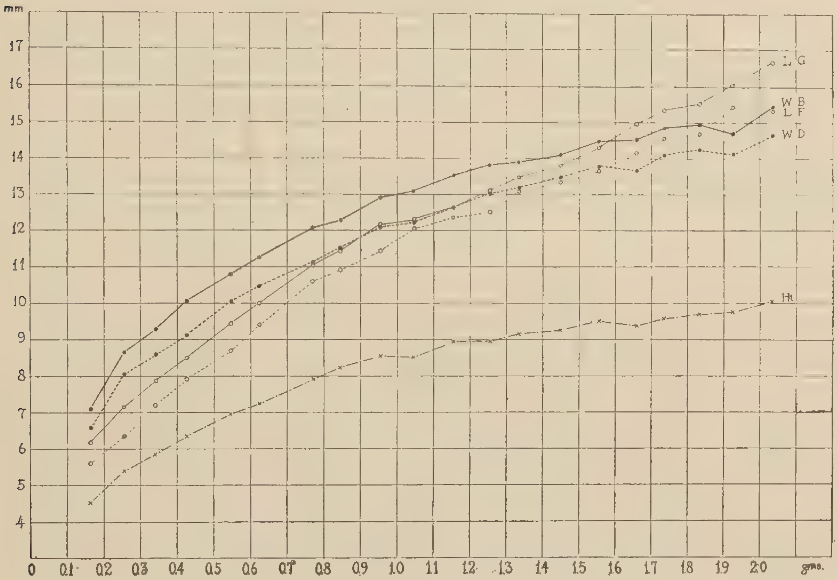

Chart 7 Giving for each brain weight group, in millimeters, on brain weight in grams, the values for the several diameters, *W.B.* and *W.D.*, width; *L.F.* and *L.G.*, length; *Ht.*, height. See equivalent designations, Figs. 3 and 3 a.

•—•—• = *W.B.* ○—○—○ = *L.G.*
•------• = *W.D.* ○------○ = *L.F.*
×-·-·×-·-·-× = *Ht.*

Using the method of equivalent ages, the fibers in the callosum of man should be well myelinated at the age of 20 months.

*Growth of the cerebral cortex in thickness* (*Sugita, '17 a*). On sections made in the three planes indicated in figures 4 and 5 the thickness of the cerebral cortex was determined at XIII localities as marked on the sagittal section in figure 6, on the frontal section in figure 7 and on the horizontal section in figure 8.

Beginning at birth, nineteen age groups were studied. The brains were fixed in Bouin's fluid and prepared by a uniform technique. The final measurements were corrected for the effects of the treatment so as to give values which apply to the fresh cortex. These are entered in table 47 and shown graphically in chart 9. The heavy line A in chart 9 shows that the final average thickness of the cortex is nearly attained at a brain

TABLE 46

*Showing the calculated callosal area at different ages of the albino rat. Data on standard body weight are taken from table 157 and the calculated callosal area determined by formula (11).*

| NUMBER OF RATS | AGE | BODY WEIGHT |  | AREA OF CORPUS CALLOSUM |  | BRAIN WEIGHT—STANDARD |
|---|---|---|---|---|---|---|
|  |  | Observed | Standard | Observed | Calculated from C. |  |
|  | A | B | C | D | E | F |
|  | *days* | *grams* | *grams* | *mm.*$^2$ | *mm.*$^2$ | *grams* |
| 1 | Birth | 4.3 | 4.7 | 1.45 | 1.58 | 0.217 |
| 2 | 5 | 6.5 | 7.6 | 2.07 | 2.02 | 0.509 |
| 3 | 7 | 9.5 | 9.5 | 2.34 | 2.22 | 0.657 |
| 4 | 10 | 7.6 | 13.5 | 2.38 | 2.54 | 0.947 |
| 5 | 12 | 27.4 | 14.4 | 3.25 | 2.60 | 0.991 |
| 6 | 15 | 15.7 | 16.1 | 2.39 | 2.71 | 1.057 |
| 7 | 17 | 21.5 | 17.3 | 2.42 | 2.77 | 1.095 |
| 8 | 20 | 31.5 | 19.5 | 2.86 | 2.87 | 1.150 |
| 9 | 22 | 29.9 | 21.1 | 2.84 | 2.94 | 1.184 |
| 10 | 25 | 26.2 | 23.9 | 3.17 | 3.06 | 1.237 |
| 11 | 27 | 27.4 | 25.9 | 3.58 | 3.13 | 1.266 |
| 12 | 30 | 29.2 | 29.2 | 3.68 | 3.25 | 1.311 |
| 13 | 35 | 27.5 | 35.4 | 3.35 | 3.42 | 1.375 |
| 14 | 40 | 59.2 | 42.5 | 4.23 | 3.59 | 1.434 |
| 15 | 50 | 75.3 | 59.6 | 4.43 | 3.90 | 1.537 |
| 16 | 60 | 76.5 | 80.3 | 4.35 | 4.15 | 1.622 |
| 17 | 70 | 75.1 | 104.7 | 3.99 | 4.42 | 1.695 |
| 18 | 80 | 103.5 | 132.8 | 4.51 | 4.63 | 1.758 |
| 19 | 90 | 100.6 | 150.5 | 4.51 | 4.76 | 1.791 |
| 20 | 100 | 101.3 | 165.8 | 4.51 | 4.85 | 1.817 |
| 21 | 112 | 133.2 | 181.6 | 4.60 | 4.94 | 1.841 |
| 22 | 122 | 134 3 | 193.1 | 4.61 | 5.01 | 1.857 |
| 23 | 150 | 159.7 | 218.7 | 4.67 | 5.12 | 1.888 |
| 24 | 205 | 220.8 | 250.9 | 5.28 | 5.25 | 1.924 |
| 25 | 378 | 274.8 | 279.9 | 5.29 | 5.36 | 1.954 |

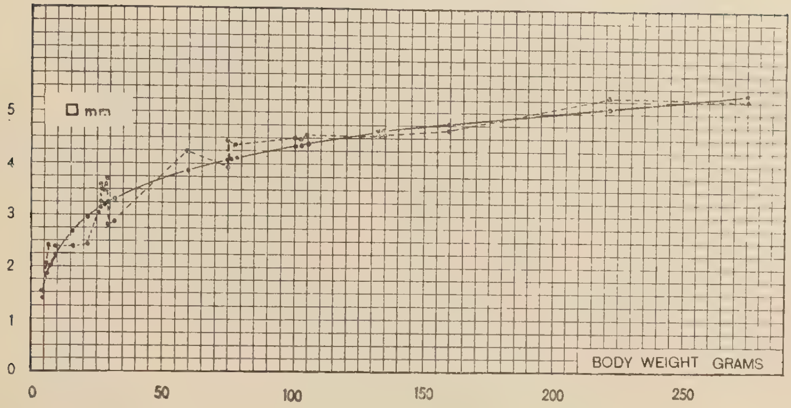

Chart 8 The continuous line represents the area of the corpus callosum according to body weight, calculated by formula (11) the broken line shows the means of the observed callosal areas. Albino rat.

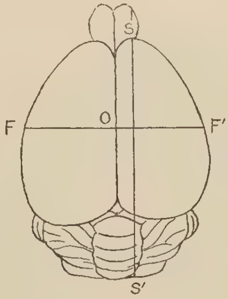

Fig. 4 Diagram of the entire brain of the albino rat seen from above, showing the levels from which the sagittal and frontal sections were taken. *SS′*, the sagittal section; *FF′*, the frontal section; *O*, middle point of the sagittal fissure.

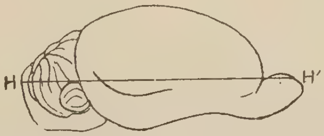

Fig. 5 Diagram of the entire brain of the albino rat, seen from the side and showing the level from which the horizontal sections were taken. *HH′*, horizontal section.

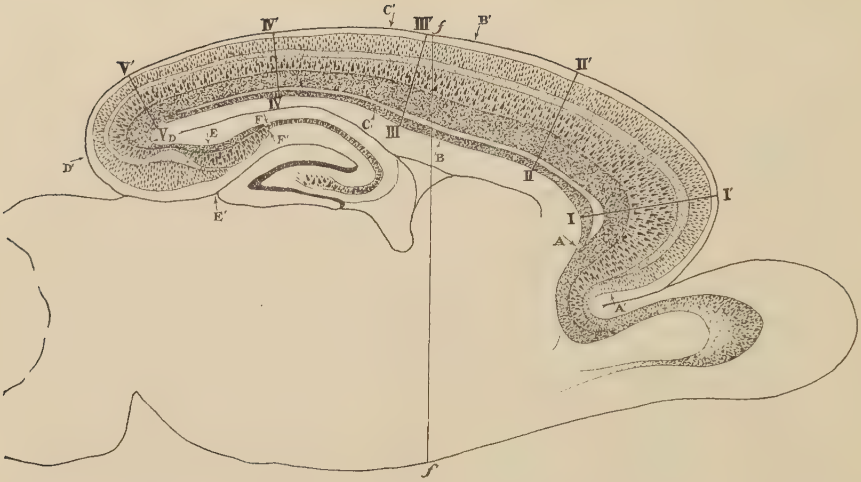

Fig. 6 Diagram of the sagittal section, from the albino rat brain weighing 1.5 grams, at about 30 days in age, showing the cell-lamination of the cortex and the localities at which the thickness of the cortex was measured. *ff'* is the level from which the frontal section was to be taken. Lines *AA'*, *BB'*, *CC'*, *DD'*, *EE'* and *FF'* indicate the borders of the areas showing different types of cell-lamination.

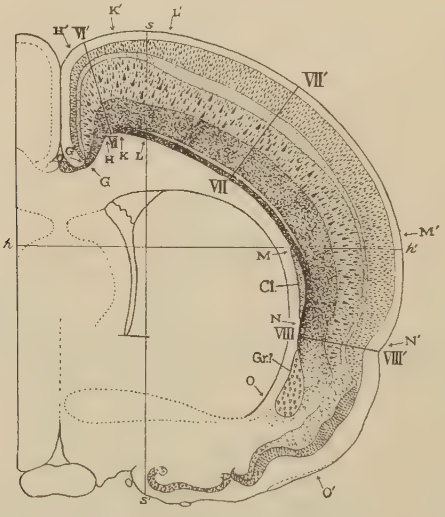

Fig. 7 Diagram of the frontal section, from the albino rat brain weighing 1.5 grams, at about 30 days in age, showing the cell-lamination of the cortex and the localities at which the thickness of the cortex was measured. *ss'*, plane in which the sagittal section was taken; *hh'*, level from which the horizontal section was taken. Lines *GG'*, *HH'*, *KK'*, *LL'*, *MM'*, *NN'* and *OO'* indicate the borders of the areas showing different types of cell-lamination. *N'* fissura rhinalis. Between *M* and *N* the claustrum—(*Cl*)—is seen. *Gr.'* marks the unidentified cell group between *NN'* and *OO'*.

weight of 1.154 grams, equivalent to 20 days of age—or the time of weaning.

*Number of cells in two layers of the cerebral cortex* (*computed*). Using two layers, the lamina pyramidalis and the lamina ganglionaris, in a selected locality VII Figure 9 (Sugita, '18 b) determined the number of cells in a unit volume of the cortex (one-thousandth of a cubic millimeter).

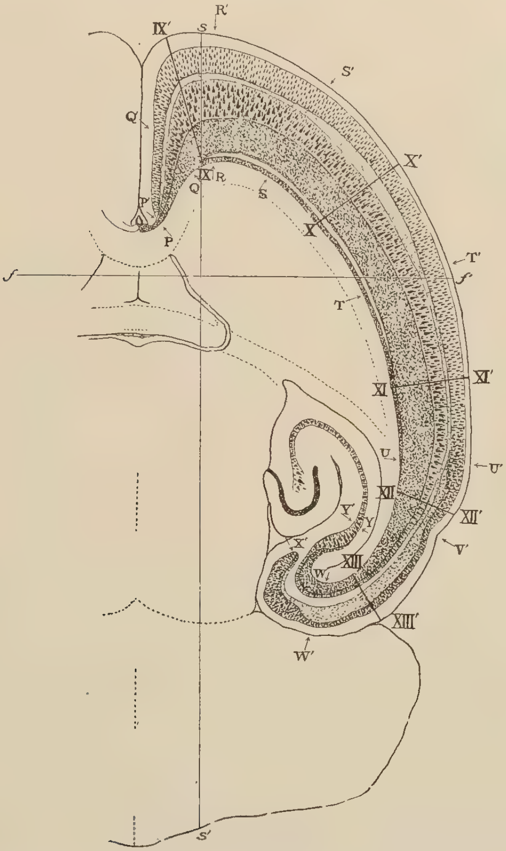

Fig. 8 Diagram of the horizontal section, from the albino rat brain weighing 1.5 grams, indicating the position of the localities measured on the section and the cortical cell-lamination. *ff'* and *ss'* show respectively the levels from which the frontal and the sagittal sections were taken. The lines *PP'*, *QQ'*, *RR'*, *SS'*, *TT'*, *UU'*, *WW'*, *X'* and *YY'* indicate the borders of areas which show differences of cell-lamination and *V'* indicates the rhinal fissure.

The number thus obtained was multiplied by the number of times the unit volume was contained in the volume of the entire cortex. The final numbers computed for each of the nineteen brain weight groups made it possible to determine when the number of cells in the cortex was complete, but in the nature of the case, these numbers, based on two layers only, have a relative rather than an absolute value. The results are given in table 48.

TABLE 47

*Showing the average (corrected) thickness of the cerebral cortex in the albino rat by brain weight groups*

| BRAIN WEIGHT GROUP | SAGITTAL SECTION | | FRONTAL SECTION | HORIZONTAL SECTION | | AVERAGE | | |
|---|---|---|---|---|---|---|---|---|
| | Brain weight | Thickness | Thickness | Brain weight | Thickness | Brain weight | Thickness | Approximate age |
| | *grams* | *mm.* | *mm.* | *grams* | *mm.* | *grams* | *mm.* | *days* |
| I | 0.161 | 0.52 | 0.56 | | | | | |
| II | 0.251 | 0.67 | 0.78 | 0.292 | 0.77 | 0.265 | 0.74 | B |
| III | 0.358 | 0.90 | 1.02 | 0.317 | 0.90 | 0.344 | 0.94 | 2 |
| IV | 0.432 | 0.99 | 1.11 | 0.419 | 1.17 | 0.428 | 1.09 | 4 |
| V | 0.542 | 1.14 | 1.33 | 0.546 | 1.28 | 0.543 | 1.25 | 6 |
| VI | 0.639 | 1.29 | 1.55 | 0.631 | 1.41 | 0.636 | 1.42 | 7 |
| VII | 0.750 | 1.43 | 1.74 | 0.761 | 1.60 | 0.754 | 1.59 | 8 |
| VIII | 0.841 | 1.48 | 1.82 | 0.848 | 1.69 | 0.843 | 1.66 | 9 |
| IX | 0.964 | 1.55 | 1.86 | 0.939 | 1.77 | 0.956 | 1.73 | 10 |
| X | 1.040 | 1.59 | 1.84 | 1.054 | 1.86 | 1.045 | 1.76 | 15 |
| XI | 1.171 | 1.72 | 1.91 | 1.121 | 1.88 | 1.154 | 1.84 | 20 |
| XII | 1.253 | 1.75 | 1.91 | 1.240 | 1.96 | 1.249 | 1.87 | |
| XIII | 1.335 | 1.72 | 1.94 | 1.351 | 1.87 | 1.340 | 1.84 | |
| XIV | 1.445 | 1.70 | 1.99 | 1.455 | 1.94 | 1.448 | 1.88 | |
| XV | 1.554 | 1.76 | 1.97 | 1.566 | 1.89 | 1.558 | 1.87 | |
| XVI | 1.656 | 1.77 | 1.94 | 1.678 | 2.00 | 1.663 | 1.90 | |
| XVII | 1.726 | 1.79 | 1.90 | 1.730 | 1.93 | 1.727 | 1.87 | |
| XVIII | 1.839 | 1.86 | 1.97 | 1.823 | 1.99 | 1.833 | 1.94 | |
| XIX | 1.924 | 1.80 | 1.83 | | | | | |
| XX | 2.054 | 1.80 | 1.72 | 2.004 | 2.21 | 2.037 | 1.91 | |

It appears from table 48 that when the computation is based on the selected laminae, the number of cells in the cortex is complete at about 20 days, or the time of weaning.

In column D of table 48 the numbers entered are only one fifty thousandth of the computed numbers. Hence, after weaning, there are, *according to this calculation*, 530 × 50,000 or 26.5 million cells in these two layers of the cerebral cortex.

*Growth in the diameters of cortical cells and their nuclei* (*Sugita, '18 c*). At the two localities shown in fig. 10 (a and b) the diameters of the largest cells and their nuclei in the lamina pyramidalis and the lamina ganglionaris were measured, in material fixed in Bouin's fluid. The ten largest cells and their nuclei in each locality were measured on two diameters. The mean diameter was determined as the square root of the product of the two diameters. As in all the other measurements made on the cortex, the direct observations were corrected for the effect of the treatment so that the values here given apply to the cells in the fresh state.

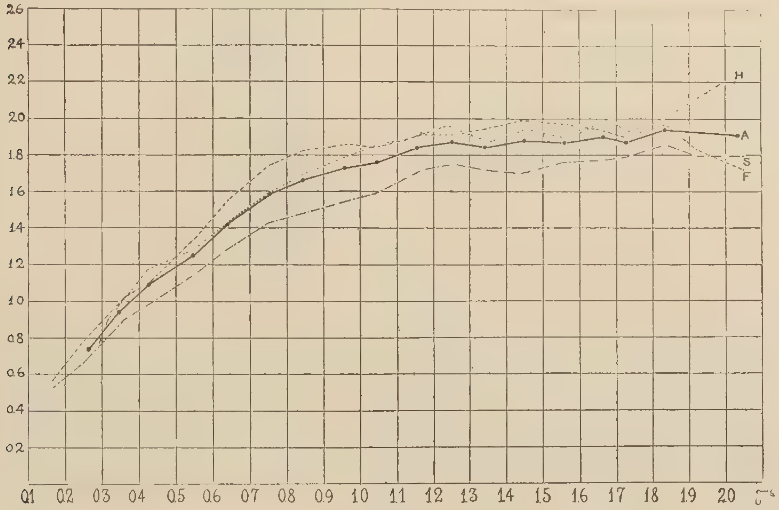

Chart 9 Giving the corrected thickness of the cerebral cortex in sagittal, frontal and horizontal sections and the general average thickness of the cortex for the three sections combined, on brain weight groups. Based on table 47.
•—•—•—*S*. Average thickness of the cortex in sagittal section. Corrected.
– – – – – *F*. Average thickness of the cortex in frontal section. Corrected.
---------*H*. Average thickness of the cortex in horizontal section. Corrected.
•———•*A*. General average thickness of the cortex for all three sections. Corrected.

Table 49 gives the mean values for each brain weight group and the same are shown graphically in chart 10.

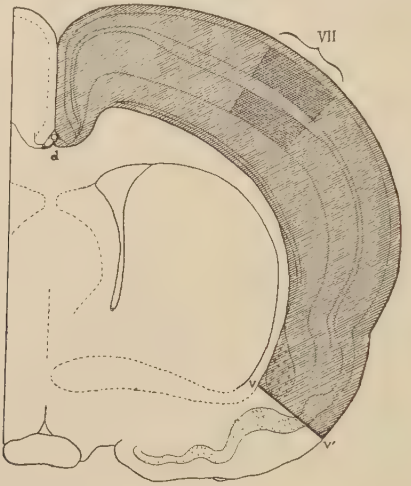

Fig. 9 Showing, by shading, the cortical area measured on the frontal section of the albino rat brain. The dorsal border *(d)* is chosen at the borderline of the corpus callosum. The ventral border *(v–v')* was drawn perpendicular to the surface at the basal end of the cell group found near the fissura rhinalis, latero-basal to the capsula externa. The double shaded part, locality VII, indicates the areas (lamina pyramidalis and lamina ganglionaris) where the cell number and cell size were determined.

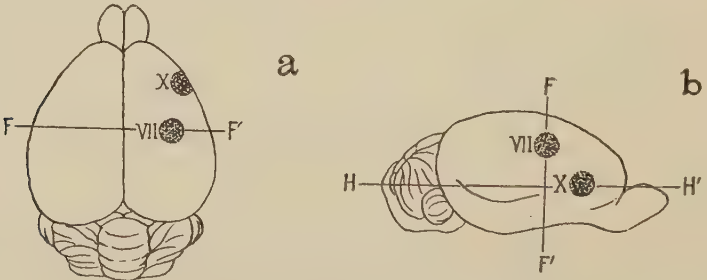

Fig. 10 Showing on the brain surface the localities at which the sizes of the pyramids and the ganglion cells were measured. *FF'* indicates the level from which the frontal section was taken and *HH'* indicates the level from which the horizontal section was taken. *VII* = locality *VII; X* = locality *X*. *a* = the dorsal view of an Albino brain weighing 1.5 grams. Enlarged 1.8 diameters. *b* = the lateral view of the same.

As the graphs show the cells in the L. ganglionaris complete their rapid growth between 10 and 20 days of age, while the cells in the L. pyramidalis are a little slower. In this latter

TABLE 48

*Giving the computed number of nerve cells in the entire cerebral cortex, obtained on the basis of the measurements given in this series of studies. The ratio of the number of cells of each later group to that Group II (birth) is also given*

| | A | B | C | D | E |
|---|---|---|---|---|---|
| BRAIN WEIGHT GROUP | BRAIN WEIGHT | COMPUTED VOLUME OF CORTEX $L.F. \times W.D \times T$ | SUM OF NOS. OF CELLS IN LAM. PYR. AND LAM. GANG. IN TWO UNIT VOLUMES, $K$ | COMPUTED NUMBER OF CELLS IN CORTEX;* $N \times L.F \times W.D \times T \times \frac{1}{100}$ | RATIO OF NUMBER OF CELLS |
| | *grams* | *mm.*$^3$ | | | |
| II (birth) | 0.251 | 35.97 | 739 | 265.8 | 1.00 |
| III | 0.358 | 61.81 | 590 | 364.7 | 1.37 |
| IV | 0.432 | 81.84 | 499 | 408.4 | 1.54 |
| V | 0.542 | 111.46 | 394 | 439.2 | 1.65 |
| VI | 0.639 | 144.50 | 305 | 440.8 | 1.66 |
| VII | 0.750 | 184.04 | 257 | 473.0 | 1.78 |
| VIII | 0.841 | 210.54 | 240 | 505.3 | 1.90 |
| IX (10 days) | 0.964 | 240.02 | 213 | 511.2 | 1.92 |
| X | 1.040 | 255.94 | 198 | 506.8 | 1.91 |
| XI (20 days) | 1.171 | 288.93 | 186 | 537.4 | 2.02 |
| XII | 1.253 | 304.51 | 171 | 520.7 | 1.96 |
| XIII | 1.335 | 314.03 | 176 | 552.7 | 2.08 |
| XIV | 1.445 | 329.71 | 165 | 544.0 | 2.05 |
| XV | 1.554 | 345.86 | 149 | 515.3 | 1.94 |
| XVI | 1.656 | 359.30 | 144 | 517.4 | 1.95 |
| XVII | 1.726 | 365.08 | 146 | 533.0 | 2.01 |
| XVIII | 1.839 | 397.96 | 138 | 549.2 | 2.07 |
| XIX | 1.924 | 390.39 | 132 | 515.3 | 1.94 |
| XX | 2.054 | 393.15 | 131 | 515.0 | 1.94 |
| Average (Groups XI–XX)........................... | | | | 530.0 | 2.00 |
| Average (Groups XIII–XX)......................... | | | | 530.2 | 2.00 |

* As explained in (footnote 4), loc. cit. the actual number of cells contained in the computed volume of the cortex should be N × L. F × W. D × T × 500, but, for the convenience, 1/100 of N- × L. F × W. D. × T, or 1/50,000 of the actual number of cells contained in the computed volume, was given here as the computed number of cells in the cortex.

TABLE 49

*Giving the corrected final average diameters of the nerve cells and their nuclei of the lamina pyramidalis and the lamina ganglionaris measured on the frontal and the horizontal sections of the albino rat brain. The average values of the two for each brain weight group are also given. The correction-coefficient for each brain weight group was taken from previous papers (Sugita, '17 a, '18 b.*

F = the frontal section. H = the horizontal section.

| BRAIN WEIGHT GROUP | BRAIN WEIGHT | LAMINA PYRAMIDALIS | | LAMINA GANGLIONARIS | |
|---|---|---|---|---|---|
| | | Cell body diameter μ | Nucleus diameter μ | Cell body diameter μ | Nucleus diameter μ |
| | *grams* | | | | |
| F I | 0.161 | 10.3 | 8.1 | 13.6 | 10.9 |
| F II<br>H II<br>(birth) | 0.272 | 12.9 | 10.6 | 18.9 | 14.9 |
| F III<br>H III | 0.338 | 15.0 | 12.6 | 20.4 | 16.2 |
| F IV<br>H IV | 0.426 | 17.4 | 14.5 | 23.4 | 18.8 |
| F V<br>H V | 0.544 | 18.2 | 15.3 | 24.9 | 19.7 |
| F VI<br>H VI | 0.635 | 19.9 | 17.0 | 26.1 | 20.9 |
| F VII<br>H VII | 0.756 | 21.3 | 18.1 | 28.1 | 21.9 |
| F VIII<br>H VIII | 0.845 | 22.6 | 19.1 | 30.1 | 23.6 |
| F IX<br>H IX<br>(10 days) | 0.952 | 22.8 | 19.8 | 30.8 | 24.3 |
| F X<br>H X | 1.047 | 23.7 | 19.7 | 31.3 | 24.4 |
| F XI<br>H XI<br>(20 days) | 1.146 | 23.6 | 19.9 | 31.2 | 24.2 |

TABLE 49—*Continued*

| BRAIN WEIGHT GROUP | BRAIN WEIGHT | LAMINA PYRAMIDALIS | | LAMINA GANGLIONARIS | |
|---|---|---|---|---|---|
| | | Cell body diameter μ | Nucleus diameter μ | Cell body diameter μ | Nucleus diameter μ |
| | *grams* | | | | |
| F XII<br>H XII | 1.247 | 24.3 | 20.3 | 31.7 | 24.5 |
| F XIII<br>H XIII | 1.343 | 23.9 | 19.7 | 31.4 | 24.0 |
| F XIV<br>H XIV | 1.450 | 23.3 | 19.3 | 31.5 | 24.2 |
| F XV<br>H XV | 1.560 | 22.9 | 18.8 | 31.5 | 24.0 |
| F XVI<br>H XVI | 1.667 | 23.0 | 19.1 | 32.4 | 24.6 |
| F XVII<br>H XVII | 1.728 | 23.1 | 19.2 | 32.5 | 24.9 |
| F XVIII<br>H XVIII | 1.831 | 22.7 | 18.8 | 32.8 | 24.6 |
| F XIX<br>H XIX | 1.924 | 22.7 | 18.2 | 33.2 | 24.6 |
| F XX<br>H XX | 2.029 | 21.6 | 17.5 | 33.5 | 24.6 |

layer the diameters of both the cells and nuclei undergo a substantial decrease from 30 days to the end of the record. Thus rapid growth of these cells in both layers is completed shortly before or shortly after weaning time. The decrease in the diameter of the pyramidal cells after the cessation of rapid growth is a phenomenon which has been observed in other cases.

In the present instance however the values have been reduced to those for the fresh cells and this makes it probable that in all these instances we are dealing with a real reduction of the size of these cells rather than with a modification, based on age, in the response of the cells to the reagents used in their preparation.

*Olfactory bulbs : number of cells.* As an average of three counts, Holt ('17) found in one olfactory bulb of the albino rat, 62–134 days of age, the number of small cells in the molecular layer to be 1,000,000 ± 2 per cent, and as an average of thirteen counts the number of mitral cells to be 76,750. The range of these counts was from 70,625 to 83,974 with $\sigma$ 4564, and P.E.M. ± 855.

The diameters of the Purkinje cells have been studied by Addison, '11.

The Albinos were from the stock colony of The Wistar Institute, reared on the scrap diet. The cerebellum was fixed in Ohlmacher's solution (King, '10) imbedded in paraffin and stained with carbol-thionine and acid fuchsin. The values for the respective diameters given in table 50 are in each instance averages of ten measurements from the largest cells found in equivalent areas at the several ages. The measurements stop at 20 days of age. After this age there is but little change in the diameters of the largest cells.

(2) *Spinal cord.* For the weight of the spinal cord see Chapter 7, p. 206, and table 144. For the percentage of water see Chapter 8, p. 308, and table 157. For the chemical composition see Chapter 9, and table 178. Cell division in the spinal cord after birth has been studied by Hamilton, '01, see table 43 and Allen ('12) see table 44.

*Peripheral—Cranio-spinal nerves.* Cranial nerves: Third nerve: Boughton ('06) studied the increase with age (body weight) in the number of myelinated fibers in the oculomotor nerve in the albino rat and measured the areas of the entire fiber and the axis in osmic preparations. The results are given in table 51.

*Fifth cranial nerve.* Nittono ('20) followed the growth in size of the neurons composing the sensory division of the trigeminus nerve (V) from birth to maturity—measuring the diameters of the largest myelinated fibers in both the sensory root and the first, second and third branches—and also the diameters of the largest cells in the ganglion. The results are given in table 52 and show that the fibers in the root have a greater diameter than those in the branches.

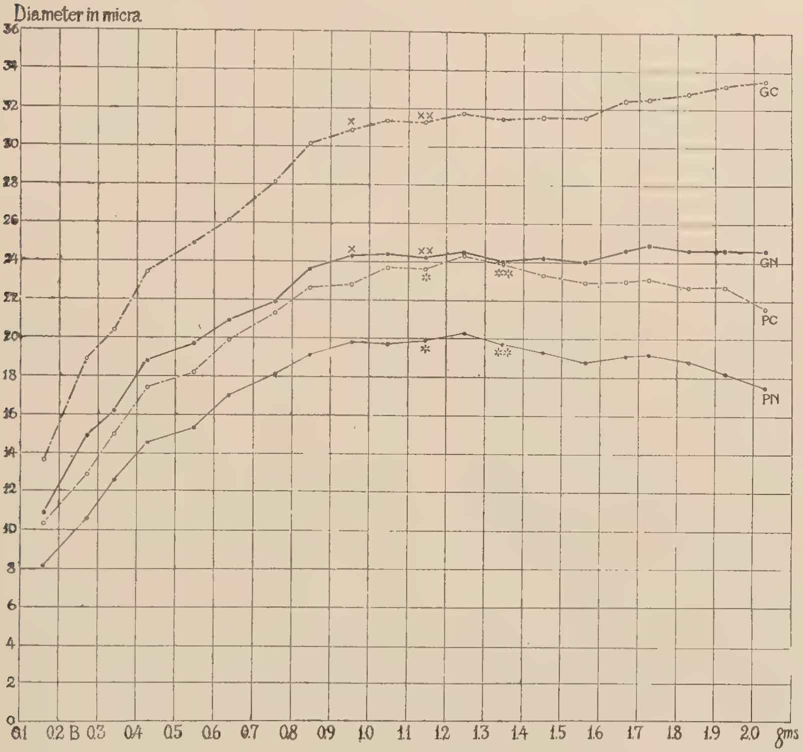

Chart 10 Showing the corrected average diameters of the cell body and the nucleus of the cortical nerve cells of the albino rat, plotted according to increasing brain weight. Based on the data in table 49. Graph *GC*, average diameter of the cell body of the ganglion cells in the lamina ganglionaris. Graph *GN*, average diameter of the nuclei of the ganglion cells in the lamina ganglionaris. Graph *PC*, average diameter of the cell body of the pyramids in the lamina pyramidalis. Graph *PN*, average diameter of the nuclei of the pyramids in the lamina pyramidalis. ×, 10 days of age. ×× and *, 20 days of age. **, 30 days of age.

The area of the axis tends to increase with age and in the fifth nerve root is on the average about half the area of the entire fiber, table 53.

TABLE 50

*Diameters of Purkinje cells and their nuclei*

| AGE IN DAYS | DIAMETERS IN $\mu$ | |
|---|---|---|
| | Cell | Nucleus |
| Birth | 12 × 7 | 8 × 6.3 |
| 3 | 14 × 8 | 8.3 × 7.4 |
| 8 | 18 × 12 | 11 × 8.5 |
| 10–20 | 21 × 14 | 12 × 9.0 |
| | (largest) 24 × 19 | |

TABLE 51

*Oculomotor nerve*

| BODY WEIGHT IN GRAMS AND SEX | NUMBER OF MYELINATED FIBERS | | | AREAS IN $\mu^2$ | | PERCENTAGE OF AXIS |
|---|---|---|---|---|---|---|
| | Large | Small | Total | Entire fiber | Axis | |
| 11 M | 764 | | 764 | | | |
| 14 M | 880 | 38 | 918 | 13.2 | 6.6 | 50 |
| 44 M | 885 | 220 | 1105 | | | |
| 51 F | 926 | 227 | 1153 | | | |
| 80 F | 887 | 290 | 1177 | 41.8 | 21.2 | 51 |
| 109 F | 888 | 329 | 1217 | | | |
| 172 M | 882 | 465 | 1347 | | | |
| 192 M | 932 | 316 | 1248 | | | |
| 213 M | 925 | 383 | 1308 | | | |
| 218 M | 926 | 471 | 1397 | | | |
| 278 M | 901 | 566 | 1467 | | | |
| 318 M | 930 | 379 | 1309 | | | |
| 414 M | 928 | 408 | 1336 | 56.7 | 27.3 | 48 |

The vertical averages for the area of the axis from the data in table 53 are:

| | | *Range* |
|---|---|---|
| First branch | 44 per cent | 40 to 48 per cent |
| Second branch | 47 per cent | 42 to 55 per cent |
| Third branch | 48 per cent | 44 to 50 per cent |
| Fifth nerve root | 50 per cent | 46 to 55 per cent |

The largest cell bodies forming the gasserian ganglion increase in diameter from birth to about puberty, reaching their maximum size at 80–100 days, after which they remain approximately constant—table 54.

TABLE 52

*Data on the diameter in μ of the largest myelinated fibers and the axis cylinders taken from three different branches and the fifth nerve root, arranged according to age*

| AGE | MEAN BODY WEIGHT | DIAMETERS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | First branch | | Second branch | | Third branch | | Fifth nerve root | |
| | | Entire fiber | Axis | Entire fiber | Axis | Entire fiber | Axis | Entire fiber | Axis |
| *days* | *grams* | | | | | | | | |
| 4 | 7.6 | 3.0 | 1.8 | 3.7 | 2.5 | 4.6 | 3.5 | 5.7 | 4.2 |
| 8 | 11.7 | 4.6 | 3.1 | 6.3 | 4.2 | 5.4 | 3.2 | 6.1 | 3.9 |
| 12 | 13.1 | 5.0 | 3.2 | 5.9 | 4.0 | 6.6 | 4.6 | 6.1 | 4.3 |
| 16 | 18.6 | 6.1 | 4.1 | 7.0 | 4.6 | 7.5 | 5.3 | 7.3 | 5.1 |
| 20 | 23.4 | 7.0 | 4.7 | 8.5 | 5.8 | 9.4 | 6.1 | 9.5 | 6.3 |
| 25 | 17.6 | 6.6 | 4.3 | 8.9 | 6.3 | 8.6 | 5.7 | 9.8 | 6.4 |
| 30 | 34.8 | 8.2 | 5.4 | 9.3 | 6.1 | 10.5 | 7.2 | 10.5 | 7.2 |
| 35 | 46.5 | 8.0 | 5.0 | 10.2 | 6.8 | 10.8 | 7.6 | 12.3 | 8.5 |
| 40 | 60.2 | 9.0 | 6.0 | 10.7 | 7.3 | 11.1 | 8.0 | 12.2 | 8.5 |
| 50 | 41.4 | 7.9 | 4.7 | 10.1 | 6.7 | 10.6 | 7.2 | 11.7 | 8.4 |
| 55 | 52.7 | 9.5 | 6.5 | 10.9 | 7.0 | 12.1 | 8.5 | 11.1 | 7.6 |
| 66 | 68.1 | 9.1 | 5.8 | 11.3 | 7.4 | 9.9 | 6.9 | 11.9 | 8.3 |
| 80 | 100.5 | 8.6 | 5.9 | 12.1 | 8.2 | 11.3 | 7.3 | 13.2 | 9.5 |
| 100 | 125.0 | 9.2 | 6.3 | 13.2 | 9.8 | 10.6 | 7.5 | 13.1 | 9.9 |
| 150 | 163.7 | 8.9 | 6.2 | 12.1 | 8.1 | 12.6 | 9.3 | 12.4 | 8.9 |
| 202 | 206.5 | 10.0 | 7.0 | 12.4 | 9.3 | 13.3 | 10.0 | 13.2 | 9.0 |
| 260 | 254.8 | 11.8 | 8.6 | 14.6 | 11.2 | 14.1 | 10.0 | 15.3 | 11.4 |
| 300 | 258.2 | 11.0 | 7.2 | 12.9 | 9.4 | 12.4 | 8.5 | 14.0 | 10.4 |
| 378 | 242.6 | 11.5 | 7.5 | 13.1 | 9.0 | 12.7 | 8.9 | 13.8 | 9.6 |
| Averages........ | | 7.6 | 5.4 | 10.2 | 7.0 | 10.2 | 7.1 | 11.0 | 7.8 |
| Ratios........... | | 1:3.8 | 1:4.2 | 1:3.5 | 1:3.6 | 1:2.8 | 1:2.5 | 1:2.4 | 1:2.3 |

The neurons in the gasserian ganglion are larger, have a higher nucleus-plasma ratio, and mature earlier than do those in the ganglion of the seventh cervical nerve. The fibers from the cells of the gasserian ganglion are absolutely less in diameter than those from the seventh cervical ganglion, despite the fact that the cell bodies of the former are larger. These differences

TABLE 53

*Showing the areas of the fibers and of the axis cylinders in $\mu^2$ in the three branches and in the fifth nerve at different ages—albino rat*

| MEAN BODY WEIGHT | AGE | FIRST BRANCH | | | SECOND BRANCH | | | THIRD BRANCH | | | FIFTH NERVE | | | HORIZONTAL AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Entire fiber | Axis | Per cent of axis | Entire fiber | Axis | Per cent of axis | Entire fiber | Axis | Per cent of axis | Entire fiber | Axis | Per cent of axis | |
| *grams* | *days* | | | | | | | | | | | | | *per cent* |
| 9.7 | 6.0 | 11.3 | 4.5 | 40 | 19.6 | 8.6 | 44 | 19.6 | 8.6 | 44 | 27.3 | 13.5 | 49 | 44 |
| 16.6 | 18.0 | 28.3 | 12.6 | 45 | 42.3 | 20.1 | 48 | 44.2 | 20.4 | 46 | 47.8 | 22.1 | 46 | 46 |
| 39.2 | 36.7 | 49.0 | 20.0 | 41 | 75.4 | 33.2 | 44 | 89.9 | 43.0 | 48 | 100.8 | 49.0 | 48 | 45 |
| 75.8 | 57.4 | 63.6 | 27.3 | 43 | 95.0 | 40.2 | 42 | 95.0 | 44.2 | 47 | 109.3 | 52.8 | 48 | 45 |
| 140.7 | 136.9 | 72.4 | 33.9 | 47 | 120.8 | 59.4 | 49 | 107.7 | 54.1 | 50 | 132.8 | 72.4 | 55 | 50 |
| 230.6 | 298.4 | 96.8 | 46.6 | 48 | 145.5 | 80.1 | 55 | 139.0 | 69.4 | 50 | 160.6 | 86.6 | 53 | 51 |
| Vertical averages per cent............ | | | | 44 | | | 47 | | | 48 | | | 50 | |

TABLE 54

*Average diameters in $\mu$ of the largest cells and their nuclei in the gasserian ganglion according to the body weight of the rats, based on the full data*

| AGE | MEAN BODY WEIGHT | COMPUTED DIAMETERS | |
|---|---|---|---|
| | | Cells | Nuclei |
| *days* | *grams* | | |
| 1 | 5.5 | 29.4 | 13.8 |
| 4 | 5.9 | 32.6 | 13.9 |
| 8 | 12.4 | 37.3 | 15.0 |
| 12 | 20.1 | 39.7 | 15.3 |
| 16 | 20.1 | 39.8 | 15.3 |
| 20 | 21.2 | 42.2 | 15.6 |
| 25 | 24.0 | 42.0 | 15.2 |
| 35 | 33.3 | 44.0 | 16.1 |
| 30 | 38.0 | 42.8 | 15.4 |
| 40 | 43.1 | 43.3 | 16.1 |
| 50 | 75.4 | 48.8 | 15.8 |
| 65 | 85.9 | 46.6 | 16.5 |
| 80 | 136.6 | 50.0 | 15.9 |
| 100 | 172.1 | 50.3 | 16.2 |
| 198 | 200.7 | 47.9 | 15.9 |
| 150 | 207.7 | 48.3 | 16.3 |
| 330 | 258.1 | 49.6 | 16.5 |
| 254 | 267.3 | 47.1 | 17.1 |
| Ratios............ | 1:48.6 | 1:1.60 | 1:1.24 |

may be related to the somewhat specialized character of the fifth nerve. See table 67.

*Eighth cranial nerve.* Droogleever Fortuyn ('14) counted 3000 myelinated fibers in the n. cochlearis of the Norway rat.

For the largest cell bodies and their nuclei in the ganglion spirale, Wada ('23) has made the determinations given in tables

TABLE 55

*Diameters of the cell bodies and their nuclei in the ganglion spirale (radial-vertical section) chart 11*

| AGE | BODY WEIGHT | BODY LENGTH | DIAMETERS IN μ | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Cell body | | | Nucleus | | |
| | | | Long | Short | Computed | Long | Short | Computed |
| *days* | *grams* | *mm.* | | | | | | |
| 1 | 5 | 48 | 11.0 | 10.0 | 10.5 | 8.2 | 7.6 | 7.9 |
| 3 | 8 | 56 | 12.0 | 11.1 | 11.5 | 8.2 | 7.8 | 8.0 |
| 6 | 11 | 63 | 13.6 | 12.3 | 12.9 | 8.8 | 8.1 | 8.4 |
| 9 | 10 | 58 | 14.3 | 12.8 | 13.6 | 8.9 | 8.2 | 8.5 |
| 12 | 13 | 70 | 14.6 | 13.1 | 13.8 | 8.7 | 8.2 | 8.5 |
| 15 | 13 | 75 | 15.7 | 14.1 | 14.9 | 9.1 | 8.4 | 8.7 |
| 20 | 29 | 95 | 19.0 | 17.3 | 18.1 | 10.3 | 10.0 | 10.2 |
| 25 | 36 | 104 | 18.5 | 16.9 | 17.7 | 10.2 | 9.9 | 10.1 |
| 50 | 59 | 125 | 18.5 | 16.6 | 17.5 | 10.3 | 9.7 | 10.0 |
| 100 | 112 | 159 | 18.1 | 15.7 | 16.9 | 9.8 | 9.2 | 9.5 |
| 150 | 183 | 190 | 18.2 | 15.3 | 16.7 | 9.6 | 8.8 | 9.2 |
| 257 | 137 | 175 | 18.5 | 15.3 | 16.8 | 9.9 | 9.4 | 9.6 |
| 366 | 181 | 191 | 18.6 | 15.3 | 16.9 | 9.8 | 9.0 | 9.4 |
| 546 | 255 | 213 | 18.6 | 15.3 | 16.9 | 9.7 | 9.0 | 9.4 |
| Ratios | | | | | | | | |
| 1— 20 days | | | | | 1:1.7 | | | 1:1.3 |
| 1—546 days | | | | | :1.6 | | | :1.2 |
| 20—546 days | | | | | :0.9 | | | :0.9 |

55 and 56 and chart 11. The values for each group are averages from observations on four cochleae. Table 56 gives the analytical constants based on the measurement of 160 cells in each age group. It may be noted that at nine days—when auditory responses may appear—the cell bodies have only about two thirds of their maximum diameter. This maximum is attained at about the end of suckling (20 days) and after that period

there is some diminution in diameter. The measurements for the nucleus follow those for the cell body.

TABLE 56

*Analytical constants giving the mean, standard deviation and coefficient of variability with their respective probable errors for the diameters of the cells and their nuclei of the ganglion spirale in radial vertical section*

| AGE | FOR TOTAL NUMBER OF CELLS | | | |
|---|---|---|---|---|
| | Cell Nucleus | Mean | Standard deviation | Coefficient of variability |
| *days* | | | | |
| 1 | Cell | 10.2 ± 0.05 | 0.90 ± 0.03 | 8.9 ± 0.33 |
| | Nucleus | 7.8 ± 0.02 | 0.46 ± 0.01 | 5.9 ± 0.22 |
| 3 | Cell | 11.3 ± 0.03 | 0.50 ± 0.02 | 4.4 ± 0.17 |
| | Nucleus | 7.9 ± 0.02 | 0.32 ± 0.01 | 4.1 ± 0.15 |
| 6 | Cell | 12.6 ± 0.04 | 0.68 ± 0.03 | 5.4 ± 0.20 |
| | Nucleus | 8.4 ± 0.03 | 0.48 ± 0.02 | 5.7 ± 0.22 |
| 9 | Cell | 13.1 ± 0.03 | 0.61 ± 0.02 | 4.7 ± 0.18 |
| | Nucleus | 8.5 ± 0.03 | 0.52 ± 0.02 | 6.1 ± 0.23 |
| 12 | Cell | 13.4 ± 0.05 | 0.86 ± 0.03 | 6.4 ± 0.24 |
| | Nucleus | 8.4 ± 0.03 | 0.61 ± 0.02 | 7.3 ± 0.28 |
| 15 | Cell | 14.6 ± 0.04 | 0.73 ± 0.03 | 5.0 ± 0.13 |
| | Nucleus | 8.7 ± 0.03 | 0.58 ± 0.02 | 6.7 ± 0.25 |
| 20 | Cell | 17.8 ± 0.06 | 1.17 ± 0.04 | 6.6 ± 0.25 |
| | Nucleus | 10.0 ± 0.02 | 0.40 ± 0.02 | 4.1 ± 0.15 |
| 25 | Cell | 17.3 ± 0.05 | 0.88 ± 0.03 | 5.1 ± 0.19 |
| | Nucleus | 9.9 ± 0.02 | 0.36 ± 0.01 | 3.6 ± 0.14 |
| 50 | Cell | 17.2 ± 0.04 | 0.78 ± 0.03 | 4.5 ± 0.17 |
| | Nucleus | 9.7 ± 0.02 | 0.34 ± 0.01 | 3.6 ± 0.14 |
| 100 | Cell | 16.5 ± 0.03 | 0.65 ± 0.02 | 3.9 ± 0.15 |
| | Nucleus | 9.4 ± 0.02 | 0.38 ± 0.01 | 4.0 ± 0.15 |
| 150 | Cell | 16.4 ± 0.03 | 0.79 ± 0.02 | 4.8 ± 0.18 |
| | Nucleus | 9.1 ± 0.02 | 0.42 ± 0.02 | 4.6 ± 0.17 |
| 257 | Cell | 16.6 ± 0.06 | 1.09 ± 0.41 | 6.6 ± 0.25 |
| | Nucleus | 9.5 ± 0.02 | 0.39 ± 0.01 | 4.1 ± 0.15 |
| 366 | Cell | 16.7 ± 0.05 | 1.02 ± 0.01 | 6.1 ± 0.22 |
| | Nucleus | 9.3 ± 0.03 | 0.52 ± 0.02 | 5.6 ± 0.21 |
| 546 | Cell | 16.7 ± 0.06 | 1.06 ± 0.04 | 6.4 ± 0.24 |
| | Nucleus | 9.3 ± 0.02 | 0.45 ± 0.02 | 4.9 ± 0.18 |

In conjunction with the studies on the ganglion spirale, Wada ('23) made, on the same material and in the same manner, a series of measurements on the largest cell bodies and their nuclei in the vestibular ganglion. The data are given in table

57 and chart 12. The analytical constants were also determined (vide loc. cit.). It may be noted that these cell bodies are larger than those of the ganglion spirale and that they are relatively well grown at birth. Further, the diameters tend to increase with age.

*Spinal nerves and ganglia.* For the study of the total number of fibers (in all the spinal nerves of one side) Agduhr '20 examined five specimens of the house rat, Mus rattus. The method used was a modification of the Bielschowsky silver technic. It was assumed that by this method all of the fibers, both myelinated and unmyelinated, were stained and so counted. The data for each nerve are given separately in the original table. Table 58 shows merely the total values.

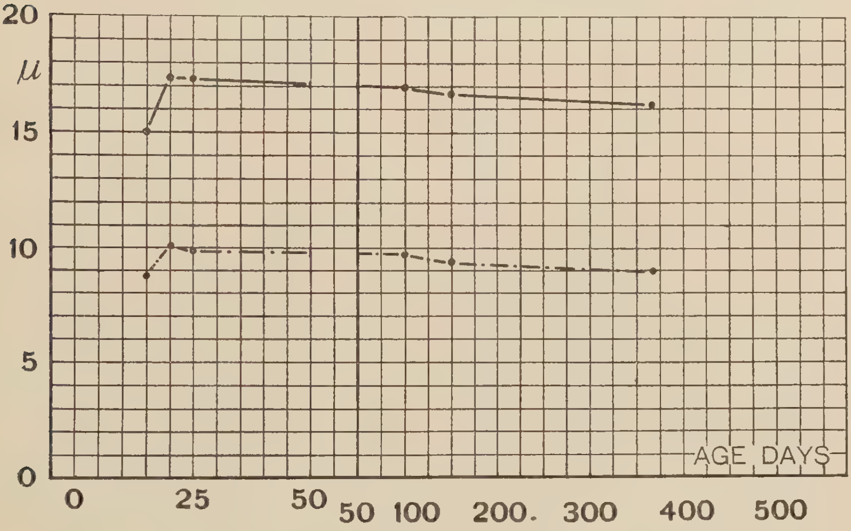

Chart 11 Showing the computed diameters of the largest cell bodies and their nuclei in the ganglion spirale—table 55.

————Diameters of cell bodies　　-·-·-Diameters of nuclei

Agduhr calls attention to the increase in the number of fibers in both roots with advancing age and body weight and to the fact that in each case the number of fibers in the dorsal roots is about twice that in the ventral.

These determinations by Agduhr show an increase in the number of fibers in the spinal nerves with advancing age, and he believes that this indicates a progressive increase in the number of neurons. His conclusions are opposed to those drawn from our own earlier studies and those made at The Institute in which it was found that the number of neurons was fixed at an early stage of development. Further investigation is needed to warrant a choice between these two views.

TABLE 57

*Diameters of the cells and their nuclei in the ganglion vestibulare in radial vertical section (chart 12)*

| AGE | BODY WEIGHT | DIAMETERS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cell Body | | | Nucleus | | |
| | | Long | Short | Computed | Long | Short | Computed |
| *days* | *grams* | | | | | | |
| | | 21.2 | 19.5 | 20.3 | 12.4 | 11.1 | 11.7 |
| 1 | 5 | 23.7 | 22.2 | 22.9 | 12.5 | 11.6 | 12.0 |
| 3 | 9 | 24.0 | 22.1 | 23.0 | 12.3 | 11.9 | 11.9 |
| 6 | 11 | 24.8 | 23.0 | 23.9 | 12.5 | 11.6 | 12.0 |
| 9 | 10 | 24.9 | 23.0 | 23.9 | 12.5 | 11.7 | 12.1 |
| 12 | 13 | 24.8 | 23.0 | 23.9 | 12.5 | 11.6 | 12.0 |
| 15 | 13 | 25.0 | 23.3 | 24.1 | 12.3 | 11.6 | 11.9 |
| 20 | 27 | 25.2 | 23.6 | 24.4 | 12.5 | 11.8 | 12.1 |
| 25 | 34 | 25.6 | 23.6 | 24.5 | 12.5 | 11.6 | 12.0 |
| 50 | 50 | 25.5 | 23.9 | 24.7 | 12.8 | 11.9 | 12.3 |
| 100 | 112 | 25.4 | 23.5 | 24.4 | 12.8 | 11.6 | 12.2 |
| 150 | 174 | 25.8 | 23.4 | 24.6 | 12.4 | 11.7 | 12.0 |
| 260 | 138 | 26.2 | 24.9 | 25.5 | 12.9 | 11.8 | 12.3 |
| 367 | 184 | 26.5 | 24.2 | 25.3 | 12.8 | 11.8 | 12.2 |
| 546 | 255 | | | | | | |
| Ratios 1—367 days | | | | 1:1.3 | | | 1:1.1 |
| 1—546 days | | | | :1.2 | | | :1.0 |
| 15—367 days | | | | :1.1 | | | :1.0 |

One of the larger spinal ganglia from a cervical nerve root of an Albino weighing 140 grams was fixed in a formalin-acetic sublimate mixture (6, loc. cit., p. 3) by Hatai ('01) and cut in paraffin sections 6–7$\mu$ thick.

Selecting cells according to size from large to small the measurements of the cell body and the nucleus were made is in table 59. The values given show the range in the size of these cells.

From a study of the diameters of the cell bodies and their nuclei in the second cervical spinal ganglion of the adult Albino, values which apply to the mean of the entire cell "population" of this ganglion have been obtained (Hatai, '07 b). The ganglion examined was from a mature male weighing 194 grams. The ganglion was fixed in osmic acid and imbedded in paraffin. The mean values are as follows—table 60.

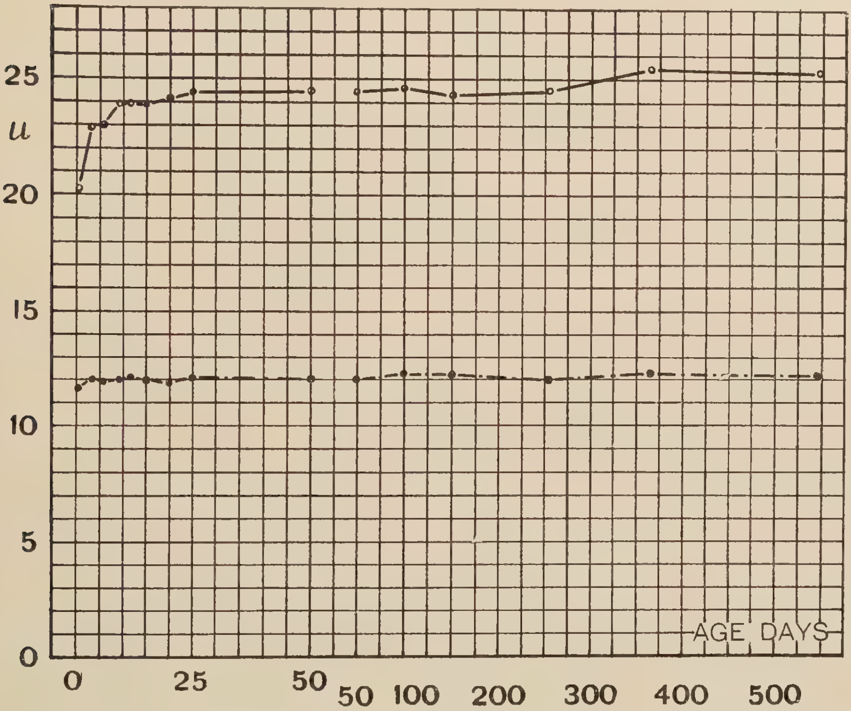

Chart 12 The diameters of the largest cell bodies and of their nuclei from the ganglion vestibulare.

———Cell bodies -·-·-·-·Nuclei

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On the basis of these observations, formula (14 a) was devised for computing the diameter of the nucleus from the diameter of the cell body.

For a comparison with the data in table 60 see data in table 59 obtained by a different method of fixation.

TABLE 58

*Total number of fibers in all the spinal nerves of one (left) side—Mus rattus*

| BODY WEIGHT | AGE | NUMBER OF FIBERS | |
|---|---|---|---|
| | | Ventral root | Dorsal root |
| *grams* | *days* | | |
| | 10 | 24,554 | 52,469 |
| | 30 | 29,258 | 51,338 |
| | 40 | 30,739 | 57,240 |
| 220 | Mother | 38,906 | 78,466 |
| 415 | Father | 53,260 | 94,109 |

TABLE 59

| SERIES | NUMBER OF CELLS | AVERAGE DIAMETERS IN μ | |
|---|---|---|---|
| | | Cell body | Nucleus |
| A | 10 | 55 × 46 | 18 × 15 |
| a | 10 | 38 × 25 | 15 × 14 |
| B | 5 | 26 × 23 | 13 × 12 |
| b | 5 | 19 × 17 | 10 × 10 |

TABLE 60

| | MEAN DIAMETER | STANDARD DEVIATION | COEFFICIENT OF VARIATION |
|---|---|---|---|
| | μ | | |
| Cell body | 28.6 | 14.9 | 18.4 |
| Nucleus | 13.1 | 1.8 | 13.7 |

Further studies on the spinal roots and ganglia were made by Hatai ('02) and ('03 b).

From a series of male Albinos the spinal ganglia with accompanying dorsal root nerves were fixed in one per cent osmic acid and cut in paraffin. The measurements on this material (Hatai, '02) are given in table 61. Incorporated in the same table are the enumerations for the myelinated fibers in the ventral roots (Hatai, '03 b).

It was found that the number of myelinated fibers in the ventral roots diminishes from sections near the spinal cord to those near the spinal ganglion. The amount of the diminution decreases with the age (body weight) of the rat. The increase in the number of cells in the spinal ganglia from the small to the large rats is certainly due in part to the fact that in the small animals some of the smallest ganglion cells escape enumeration.

TABLE 61

*Number of ganglion cells and number and size of myelinated root fibers in spinal nerves from three levels of the spinal cord at five ages (body weights)*

Results from Tables II, VI and VIII combined—Hatai ('02)
Also data on ventral root fibers from Hatai ('03 b)

| BODY WEIGHT IN GMS. | | TOTAL OF MYELINATED VENTRAL ROOT FIBERS | TOTAL OF GANGLION CELLS | TOTAL OF MYELINATED DORSAL ROOT FIBERS | TOTAL COMPOSED OF MATURE FIBERS | IMMATURE FIBERS | MEAN DIAMETER IN μ OF 20 *largest* DORSAL ROOT FIBERS ENTIRE |
|---|---|---|---|---|---|---|---|
| VI Cervical | 10.3 | 558 | 10996 | 1998 | 1043 | 955 | 7.5 |
| | 24.5 | 1007 | 9793 | 2569 | 2263 | 306 | 11.6 |
| | 68.5 | 1302 | 11772 | 3683 | 3569 | 114 | 13.3 |
| | 167.0 | 1474 | 12200 | 4227 | 4173 | 54 | 13.9 |
| | 264.3 | 1522 | | 4028 | | | |
| IV Thoracic | 10.3 | 286 | 7142 | 607 | 283 | 424 | 4.8 |
| | 24.5 | 434 | 7068 | 683 | 497 | 366 | 7.1 |
| | 68.5 | 561 | 7611 | 1420 | 1259 | 161 | 8.9 |
| | 167.0 | 613 | 7406 | 1522 | 1460 | 82 | 11.6 |
| | 264.3 | 772 | | 1650 | | | |
| II Lumbar | 10.3 | 333 | 8315 | 733 | 303 | 420 | 5.1 |
| | 24.5 | 698 | 8200 | 911 | 678 | 233 | 8.0 |
| | 68.5 | 704 | 9514 | 1317 | 1181 | 136 | 11.3 |
| | 167.0 | 1028 | 9442 | 1644 | 1565 | 79 | 12.0 |
| | 264.3 | 965 | | 2102 | | | |

The increase in the number of myelinated fibers in the spinal roots with advancing age is considered to be due, mainly, to progressive myelination. Both roots at maturity still contain functional fibers without myelin sheaths (Ranson, '06).

For the numerical relations of cells and fibers in the second cervical nerve data are furnished by Ranson ('06). Table 62.

When the number of myelinated fibers in the two rami on the distal side of the II cervical spinal ganglion is compared with the total number counted in the two roots—a distal excess in the number of fibers is found. This is shown in table 63. The distal excess appears to be due to branching of the fibers in their course, Ranson ('06).

TABLE 62

*Second cervical nerve*

*Observations on normal male rats (Albinos). Osmic acid fixation—paraffin sections*

| AGE IN DAYS | BODY WEIGHT | CELLS IN GANGLION | NUMBER OF MYELINATED FIBERS | |
|---|---|---|---|---|
| | | | Dorsal root | Ventral root |
| 72 | 110 | 7721 | 2472 | 689 |
| 72 | 110 | 8116 | 2394 | 660 |
| 72 | 110 | | 1959 | 590 |
| 72 | 110 | | 2217 | 591 |
| 72 | 155 | 9343 | | |
| | 161 | | 2090 | 672 |
| 240 (left side) | 188 | 8624 | 2689 | 703 |
| 240 (right side) | 188 | | 2891 | 773 |
| | 302 | | 2386 | 646 |

TABLE 63

| BODY WEIGHT | IN ROOTS | | | DISTAL EXCESS | | IN RAMI | | |
|---|---|---|---|---|---|---|---|---|
| | Ventral | Dorsal | Sum | Absolute | Percentage | Sum | Ventral Ramus | Dorsal Ramus |
| *grams* | | | | | | | | |
| 161 | 672 | 2090 | 2762 | 336 | 12 | 3098 | 708 | 2390 |
| 302 | 646 | 2386 | 3032 | 257 | 8 | 3289 | 887 | 2402 |

Enumerations of the myelinated fibers in the ventral roots of the II spinal nerve of the Albino have been made by Dunn ('12). Each record is the mean of two enumerations of rats of like age. Areas in $\mu^2$ of the entire fiber and of the axis are given—together with the percentage value of the axis. Each entry is based on the mean of the 20 largest fibers. In this series there is a change in the relative area of the axis with age, as well as a decrease in the total areas in the oldest group—table 64.

TABLE 64

*Giving for Albinos of different ages the numbers of myelinated fibers in the ventral root of the second cervical nerve and the areas of the fibers. Dunn ('12)*

| AGE, NUMBER, SEX | WEIGHT | NUMBER FIBERS | AVERAGE AREA TEN LARGEST FIBERS IN $\mu^2$ | AVERAGE AREA OF AXES IN $\mu^2$ | PERCENTAGE OF AXIS |
|---|---|---|---|---|---|
| | *grams* | | | | |
| 7 days | | | | | |
| Two females.... | 8.59 | 368 | 17.2 | 10.6 | 61.6 |
| Two males..... | 9.33 | 366 | 22.3 | 13.9 | 62.3 |
| 14 days | | | | | |
| Two females.... | 20.92 | 542 | 38.5 | 18.1 | 47.0 |
| Two males..... | 21.33 | 565 | 32.9 | 15.2 | 46.2 |
| 36 days | | | | | |
| Two females.... | 42.24 | 653 | 78.2 | 31.2 | 40.0 |
| Two males..... | 41.93 | 613 | 80.6 | 31.7 | 39.3 |
| 75 days | | | | | |
| Two females.... | 136.70 | 560 | 115.4 | 49.6 | 43.0 |
| Two males..... | 169.55 | 668 | 116.9 | 52.8 | 45.1 |
| 132 days | | | | | |
| Two females.... | 164.26 | 683 | 136.0 | 59.3 | 43.6 |
| Two males..... | 267.00 | 625 | 141.0 | 63.2 | 44.8 |
| 180 days | | | | | |
| Two females.... | 212.50 | 518 | 168.8 | 75.9 | 44.9 |
| Two males..... | 264.80 | 609 | 201.3 | 98.2 | 48.7 |
| 270 days | | | | | |
| Two females.... | 176.91 | 776 | 261.0 | 133.4 | 51.3 |
| Two males..... | 340.05 | 617 | 216.8 | 107.1 | 49.4 |
| 640 days | | | | | |
| Three males.... | 334.47 | 864 | 170.7 | 78.2 | 45.8 |

The number of myelinated fibers in the peroneal nerve of the normal Albino is given from Greenman's observations ('17) in table 65.

The data are arranged in age groups and are for Albinos of normal size for their ages. In some cases the body weight at killing was below normal, owing to lung infection.

The data show approximately the same number of fibers on each side. No sex difference was found. There is an indication of a loss of fibers after 251 days. This was possibly due to lung infection.

TABLE 65

*Number of myelinated fibers in the peroneal nerve of the albino rat—sections from the middle level; based on Greenman's table 8, '17*

| NUMBER OF CASES | AGE | NUMBER OF MYELINATED FIBERS | | |
|---|---|---|---|---|
| | | Right | Left | Average |
| | *days* | | | |
| 10 | 150 | 2046 | 2028 | 2037 |
| 13 | 152 | 2036 | 2044 | 2040 |
| 2 | 159 | 2167 | 2133 | 2150 |
| 2 | 251 | 2240 | 2263 | 2251 |
| 3 | 335 | 2129 | 2057 | 2093 |
| 3 | 454 | 2020 | 1922 | 1971 |

TABLE 66

*Normal albinos: Sectional area of ten largest fibers in* $\mu^2$*; relation of axis to sheath*

| BODY WEIGHT | PROXIMAL END | | | DISTAL END | | |
|---|---|---|---|---|---|---|
| | Entire fiber | Axis | Per cent of axis | Entire fiber | Axis | Per cent of axis |
| 104 | 109.8 | 55.6 | 50.6 | 85.0 | 42.3 | 49.7 |
| 117 | 137.7 | 75.2 | 54.6 | 85.8 | 42.6 | 49.6 |
| 182 | 150.3 | 82.9 | 55.1 | 113.0 | 56.7 | 50.1 |
| Average 135 | 132.6 | 71.2 | 53.7 | 94.6 | 47.2 | 49.9 |

In an earlier study on cross sections of the largest fibers Greenman ('13) found the percentage value of the area of the axis in osmic acid preparations to be 49.9 per cent, as given in table 66.

These areas were computed from the mean diameters of the entire fiber and of the axis. In this later study (Greenman, '17) the areas of axis and of entire fiber were obtained planimetrically. This method tends to give a greater value for the area of the sheath and hence to reduce the relative area of the axis, which was here found to be about 40 per cent of the entire fiber.

Using the cells and fibers from the localities shown in figure 11 a comparison has been made between the growth of the spinal ganglion cells and their fibers and the corresponding ventral horn cells and their fibers—at the level of the seventh cervical nerve (Donaldson and Nagasaka, '18). The fibers were fixed in osmic acid and the cells in Bouin's fluid. Twelve body weight groups were studied. The relations found can be best presented in tables 67 and 68 in which the body weight groups are reduced to four.

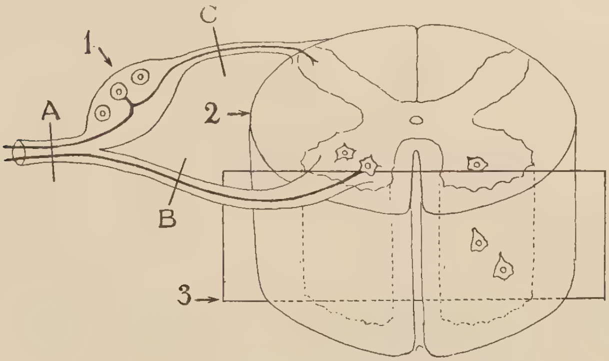

Fig. 11 A scheme of the seventh cervical segment of the spinal cord. Levels of the nerve-fiber sections: At *A*, section of seventh nerve; at *B*, section of ventral root; at *C*, section of dorsal root. 1. The spinal ganglion, cut in longitudinal section. 2. Transverse section of segment. 3. Plane of longitudinal section of the segment.

The ratios here given show that the increase in the diameters of the fibers has been nearly the same in all three cases. The increase of the spinal ganglion cells in diameter follows that of their fibers, while in the case of the ventral horn cells, the increase is much less than that of the ventral root fibers—as the growth in these cells is slight after puberty.

Thus within the limits here taken the ganglion cells continue to increase in diameter with the growth of the rat, while the fibers arising from them increase slightly more.

The enlargement of the ganglion cells is accompanied by a relative overgrowth of the cytoplasm. A study of the volume of these cells shows it to increase in proportion to the area of the skin to which the fibers are distributed—and the area of the axes of the afferent fibers also increases in proportion to the increase of skin area.

TABLE 67

*Comparing the diameters of the spinal ganglion cells in albino rats of different sizes with the diameters of the corresponding dorsal root fibers and of the fibers just distal to the ganglion. In the last two columns are given the respective ratios. Data condensed from tables 2 and 3 (loc. cit.)*

| AVERAGE BODY WEIGHT | AVERAGE AGE | AVERAGE DIAMETERS OF NERVE CELLS IN SPINAL GANGLION | AVERAGE DIAMETERS OF DORSAL ROOT FIBERS AT (C) | AVERAGE DIAMETERS OF FIBERS DISTAL TO THE GANGLION AT (A) | RATIOS | |
|---|---|---|---|---|---|---|
| | | | | | C:Sp. G. | A:Sp. G. |
| *grams* | *days* | μ | μ | μ | | |
| 29.0 | 24 | 23.5 | 10.8 | 10.7 | 1:2.18 | 1:2.20 |
| 85.1 | 56 | 29.8 | 13.0 | 12.9 | 1:2.29 | 1:2.31 |
| 149.2 | 105 | 33.4 | 15.7 | 15.8 | 1:2.13 | 1:2.11 |
| 264.2 | 267 | 38.1 | 18.3 | 18.1 | 1:2.08 | 1:2.10 |
| Ratios....... | | 1:1.6 | 1:1.7 | 1:1.7 | | |

TABLE 68

*Comparing the computed diameters of the spinal cord cells in albino rats of different sizes with the diameters of the corresponding ventral root fibers. In the last column are given the ratios. Data condensed from tables 2 and 6 (loc. cit.)*

| AVERAGE BODY WEIGHT | AVERAGE AGE | AVERAGE DIAMETERS OF SPINAL CORD CELLS. MEAN FROM TRANSVERSE AND LONGITUDINAL SECTIONS | AVERAGE DIAMETER OF VENTRAL ROOT FIBERS AT (B) | RATIOS |
|---|---|---|---|---|
| | | | | B: Sp. C. C. |
| *grams* | *days* | | | |
| 29.0 | 24 | 24.5 | 10.7 | 1:2.29 |
| 85.1 | 56 | 27.9 | 12.7 | 1:2.20 |
| 149.5 | 105 | 29.4 | 15.5 | 1:1.90 |
| 264.8 | 267 | 29.2 | 18.2 | 1:1.60 |
| Ratios........ | | 1:1.2 | 1:1.7 | |

The growth of large ventral horn cells is comparatively slight and the nucleus-plasma relation remains nearly constant—but the area of the axones of the ventral root fibers increases with the increase in the mass of muscle innervated (loc. cit).

*Axis sheath relation.* In the case of the fibers in the ventral spinal roots, the dorsal roots and the seventh nerve, the percentage area of the axis, determined by the method of diameters, is shown in table 69. In all three localities the values are similar. They increase slightly after 24 days of age but after puberty approximate 50 per cent. These results agree with those previously obtained by Dunn ('12) when the relations at like ages are compared.

TABLE 69

*Giving the areas of nerve fibers and their axes in square micra—also the percentage of the total area occupied by the axis, based on groups of three*

| AVERAGE BODY WEIGHT | AGE | VENTRAL ROOT FIBERS | | | DORSAL ROOT FIBERS | | | IN THE SEVENTH CERVICAL DISTAL TO THE SPINAL GANGLION | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Areas | | Per cent area of axis | Areas | | Per cent area of axis | Areas | | Per cent area of axis |
| | | Ent. F. | Axis | | Ent. F. | Axis | | Ent. F. | Axis | |
| *grams* | *days* | | | | | | | | | |
| 29.0 | 24 | 89.9 | 36.3 | 40 | 91.6 | 37.4 | 41 | 89.9 | 36.3 | 40 |
| 85.1 | 56 | 126.6 | 51.5 | 41 | 132.7 | 56.7 | 43 | 130.6 | 56.7 | 43 |
| 149.2 | 105 | 188.6 | 91.6 | 48 | 193.5 | 88.3 | 46 | 196.0 | 89.9 | 46 |
| 264.2 | 267 | 260.0 | 126.6 | 49 | 262.9 | 141.0 | 53 | 257.2 | 134.7 | 52 |

*Sympathetic.* In the course of a study intended primarily to determine whether the small myelinated fibers in the spinal accessory could be regarded as representing the fibers of the rami communicantes, Roth ('05) in a series of cervical nerves, counted on one side the number of myelinated fibers 4 μ or less in diameter, and in the corresponding ramus communicans he also counted the myelinated fibers of like size. His findings are given in table 70.

In the standard strain of the albino rat from The Institute the cell bodies in the superior cervical sympathetic ganglion grow rapidly for the first twenty-five days after birth—then more slowly. After puberty the cells are slightly larger in the female (Ping, '21)—table 71.

In the inbred strain (Dr. King) the size of both the cells and the nuclei was slightly greater in the female. On the other hand while the nuclei are but little smaller than in the standard strain, the cells have but 80 per cent of the diameter and therefore only half the volume of those in the standard strain. The nucleus-plasma ratio is correspondingly reduced.

*Technical methods.* To determine the effects of various fixatives on the brain of the rat, King ('10) carried through a series of weighings of mature rat brains which had been subjected to the action of various fixatives. A summary of the results is given in table 72.

TABLE 70

| NERVE | MYELINATED FIBERS LESS THAN 4 μ IN DIAMETER IN VENTRAL ROOT | | MYELINATED FIBERS LESS THAN 4 μ IN RAMUS COMMUNICANS |
|---|---|---|---|
| | Rat I | Rat II | |
| 2nd cervical | 130 | 168 | None |
| 3rd cervical | 105 | 126 | None |
| 4th cervical | 380 | 363 | 195 |
| 5th cervical | 432 | 449 | 220 |

The solution of Ohlmacher ('97), the formula for which is as follows:

Absolute alcohol, 80 parts.
Chloroform, 15 parts.
Glacial acetic acid, 5 parts.

Corrosive sublimate to saturation (about 20 per cent) was found to give excellent results with the cells of the cerebral cortex.

In a later study King ('13 a) followed in some detail the effects of formaldehyde on the brain of the Albino. The conclusions reached were as follows:

1. A 4 per cent solution of formaldehyde causes a pronounced swelling in the brains of rats of all ages.
2. A solution of formaldehyde undergoes some chemical change on standing, since a solution five months old causes less swelling in the brain of the rat than does a freshly made solution.

TABLE 71

*Computed diameters of the largest cells and nuclei—on body weight—together with the nucleus plasma ratios—from the superior cervical sympathetic ganglion of the albino rat (standard strain)*

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| SEX | AGE | BODY WEIGHT | BODY LENGTH | Computed diameter in μ | | NUCLEUS PLASMA RATIOS |
| | | | | Cell | Nucleus | |
| | *days* | *grams* | *mm.* | | | |
| ♂ | 1 | 5.6 | 50 | 19.5 | 11.4 | 1: 4.0 |
| ♀ | 1 | 6.3 | 51 | 19.8 | 10.2 | 1: 6.3 |
| ♂ | 5 | 9.0 | 63 | 22.1 | 10.7 | 1: 7.8 |
| ♀ | 5 | 11.0 | 65 | 21.3 | 10.5 | 1: 7.3 |
| ♀ | 11 | 14.0 | 73 | 26.4 | 13.1 | 1: 7.2 |
| ♂ | 11 | 15.0 | 77 | 24.9 | 13.1 | 1: 5.8 |
| ♀ | 29 | 16.4 | 82 | 24.8 | 12.2 | 1: 6.8 |
| ♂ | 16 | 18.9 | 83 | 25.3 | 13.1 | 1: 6.2 |
| ♀ | 16 | 19.0 | 81 | 23.1 | 11.2 | 1: 7.7 |
| ♂ | 25 | 23.8 | 93 | 26.6 | 12.6 | 1: 8.4 |
| ♀ | 25 | 25.5 | 95 | 27.3 | 12.7 | 1: 8.9 |
| ♀ | 20 | 29.5 | 99 | 23.6 | 11.8 | 1: 7.0 |
| ♂ | 20 | 31.7 | 102 | 26.4 | 12.5 | 1: 8.0 |
| ♂ | 29 | 40.7 | 112 | 27.1 | 12.0 | 1:10.5 |
| ♀ | 42 | 43.5 | 105 | 27.2 | 13.2 | 1: 7.7 |
| ♀ | 48 | 49.7 | 120 | 27.0 | 13.1 | 1: 7.7 |
| ♂ | 60 | 51.6 | 124 | 27.2 | 13.2 | 1: 7.7 |
| ♀ | 62 | 53.8 | 117 | 27.1 | 13.1 | 1: 7.8 |
| ♂ | 42 | 61.4 | 129 | 27.0 | 13.4 | 1: 7.2 |
| ♂ | 81 | 63.3 | 128 | 27.4 | 13.3 | 1: 7.5 |
| ♀ | 88 | 73.0 | 135 | 29.2 | 13.2 | 1: 9.8 |
| ♀ | 80 | 83.7 | 142 | 26.6 | 12.8 | 1: 7.9 |
| ♀ | 250 | 98.0 | 160 | 30.6 | 14.2 | 1: 9.0 |
| ♂ | 48 | 105.1 | 156 | 29.0 | 13.4 | 1: 9.1 |
| ♀ | 124 | 107.1 | 157 | 30.5 | 13.8 | 1: 9.8 |
| ♀ | 171 | 123.8 | 159 | 30.9 | 12.8 | 1:13.1 |
| ♀ | 570 | 127.1 | 169 | 33.4 | 14.3 | 1:11.7 |
| ♂ | 89 | 143.5 | 173 | 32.4 | 13.0 | 1:14.4 |
| ♂ | 124 | 151.1 | 174 | 27.1 | 13.0 | 1: 8.0 |
| ♀ | 540 | 151.3 | 184 | 30.7 | 13.4 | 1:11.0 |
| ♀ | 365 | 170.6 | 186 | 31.4 | 13.5 | 1:11.6 |
| ♂ | 365 | 186.0 | 203 | 29.6 | 13.5 | 1: 9.5 |
| ♂ | 171 | 198.2 | 192 | 27.0 | 13.1 | 1: 7.7 |
| ♂ | 250 | 230.0 | 207 | 36.8 | 15.4 | 1:12.6 |

TABLE 72

*Summary of data collected (King '10)*

| RAT NUMBER | SEX | BODY WEIGHT IN GRAMS | BODY LENGTH IN MM. | NORMAL WEIGHT OF FRESH BRAIN COMPUTED | SOLUTIONS USED FOR FIXATION | NUMBER HOURS SOLUTIONS ACTED | WEIGHT OF BRAIN IN GRAMS WHEN REMOVED FROM SOLUTION | PER CENT GAIN OR LOSS IN WEIGHT | WEIGHT OF BRAIN IN GRAMS AFTER REMAINING IN 70% ALCOHOL FOR 48 HOURS | PER CENT GAIN OR LOSS IN WEIGHT |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ♂ | 277 | 219 | 1.94 | 4% Formaldehyde... | 48 | 2.5750 | +33 | 1.5706 | −19 |
| 2 | ♂ | 163 | 196 | 1.83 | 4% Formaldehyde... | 48 | 2.8200 | +54 | 1.6463 | −10 |
| 3 | ♀ | 158 | 199 | 1.85 | Formol-Müller (cold) | 20 | 2.2437 | +21 | 1.5537 | −16 |
| 4 | ♀ | 129 | 183 | 1.78 | 4% Formaldehyde... | 48 | 2.6778 | +50 | 1.6577 | − 7 |
| 5 | ♀ | 164 | 188 | 1.80 | Formol-Müller (warm)............ | 3 | 2.1880 | +22 | 1.8711 | + 4 |
| 6 | ♂ | 187 | 198 | 1.85 | Ohlmacher........... | 5 | 1.6100 | −12 | 1.4471 | −22 |
| 7 | ♀ | 137 | 184 | 1.78 | Ohlmacher........... | 2 | 1.7389 | − 2 | 1.4099 | −21 |
| 8 | ♂ | 160 | 190 | 1.81 | Zenker.............. | 6 | 1.8716 | + 3 | 1.6666 | − 8 |
| | | | | | Müller.............. | 48 | | | | |
| 9 | ♀ | 170 | 197 | 1.84 | Dahlgren.. ........ | 4 | 1.9000 | + 3 | 1.7273 | − 7 |
| | | | | | Müller......... .... | 48 | | | | |
| 10 | ♂ | 182 | 186 | 1.79 | Picro-formol......... | 4 | 1.7881 | − 0 | 1.4663 | −18 |
| 11 | ♂ | 275 | 228 | 1.98 | Ohlmacher........... | 6 | 1.8267 | − 8 | 1.6248 | −18 |
| 12 | ♂ | 206 | 207 | 1.88 | Ohlmacher........... | 2 | 1.6924 | −10 | 1.5748 | −16 |
| 13 | ♂ | 228 | 210 | 1.90 | Ohlmacher........... | 4 | 1.5787 | −17 | 1.4498 | −25 |
| 14 | ♂ | 169 | 194 | 1.83 | Ohlmacher........... | 3 | 1.5458 | −16 | 1.4633 | −20 |
| 15 | ♂ | 126 | 157 | 1.65 | Ohlmacher........... | 3 | 1.3978 | −16 | 1.3099 | −21 |
| 16 | ♂ | 158 | 181 | 1.77 | Ohlmacher........... | 3 | 1.4590 | −18 | 1.4000 | −21 |
| 17 | ♂ | 232 | 199 | 1.85 | Ohlmacher........... | 3 | 1.6390 | −11 | 1.4875 | −20 |
| 18 | ♀ | 111 | 154 | 1.63 | Zenker-formol........ | 1½ | 1.6040 | − 2 | 1.3297 | −18 |
| 19 | ♀ | 106 | 159 | 1.66 | Zenker (modified).... | 1¼ | 1.7451 | + 5 | 1.3167 | −21 |
| 20 | ♂ | 6 | | 0.30 | Ohlmacher........... | 1 | 0.2523 | −16 | 0.2074 | −31 |
| 21 | ♀ | 6 | | 0.29 | Ohlmacher........... | 2 | 0.2489 | −14 | 0.2011 | −30 |
| 22 | ♂ | 108 | 156 | 1.64 | 2½% $K_2Cr_2O_7$......... | 48 | 2.8445 | +73 | 2.1409 | +31 |
| 23 | ♂ | 88 | 163 | 1.68 | 2½% $K_2Cr_2O_7$......... | 48 | 2.5594 | +52 | 1.7518 | + 4 |
| 24 | ♂ | 162 | 187 | 1.79 | Alcohol $K_2Cr_2O_7$..... | 48 | 2.5073 | +40 | 1.8885 | + 6 |
| 25 | ♂ | 190 | 207 | 1.88 | Alcohol $K_2Cr_2O_7$..... | 48 | 2.8169 | +50 | 2.1797 | +16 |
| 26 | ♂ | 174 | 184 | 1.78 | Weak alcohol......... | 27 | 1.7753 | −00 | 1.6201 | − 9 |
| 27 | ♂ | 168 | 191 | 1.81 | Alcohol-formol....... | 24 | 1.6392 | −10 | 1.5147 | −16 |
| 28 | ♂ | 221 | 198 | 1.85 | 95% Alcohol......... | 24 | 1.4418 | −22 | 1.4611 | −21 |
| 29 | ♂ | 151 | 184 | 1.78 | Sublimate-acetic..... | 1½ | 1.8604 | + 5 | 1.4484 | −19 |
| 30 | ♂ | 213 | 202 | 1.86 | Carnoy's fluid........ | 3 | 1.8192 | + 2 | 1.4077 | −24 |
| 31 | ♂ | 181 | 194 | 1.82 | Carnoy's fluid........ | 4 | 1.7575 | − 3 | 1.3042 | −23 |
| 32 | ♀ | 141 | 178 | 1.75 | Graf (5% formalin). | 2½ | 2.1520 | +23 | 1.7421 | −00 |
| 33 | ♂ | 165 | 191 | 1.81 | Graf (10% formalin). | 1½ | 1.9283 | + 7 | 1.5994 | −12 |
| 34 | ♀ | 149 | 184 | 1.77 | Carnoy's fluid........ | 19 | 1.7416 | − 2 | 1.3110 | −28 |

TABLE 72—*Concluded*

| RAT NUMBER | SEX | BODY WEIGHT IN GRAMS | BODY LENGTH IN MM. | NORMAL WEIGHT OF FRESH BRAIN COMPUTED | SOLUTIONS USED FOR FIXATION | NUMBER HOURS SOLUTIONS ACTED | WEIGHT OF BRAIN IN GRAMS WHEN REMOVED FROM SOLUTION | PER CENT GAIN OR LOSS IN WEIGHT | WEIGHT OF BRAIN IN GRAMS AFTER REMAINING IN 70% ALCOHOL FOR 48 HOURS | PER CENT GAIN OR LOSS IN WEIGHT |
|---|---|---|---|---|---|---|---|---|---|---|
| 35 | ♀ | 167 | 189 | 1.80 | Lang's fluid.......... | 20 | 2.0670 | +15 | 1.6794 | − 7 |
| 36 | ♂ | 208 | 203 | 1.86 | Lang's fluid.......... | 4 | 2.0429 | +10 | 1.7970 | − 3 |
| 37 | ♀ | 173 | 194 | 1.82 | Marina's fluid........ | 72 | 1.2219 | −33 | 1.2913 | −29 |
| 38 | ♂ | 197 | 201 | 1.86 | Marina's fluid........ | 96 | 1.2146 | −35 | 1.2546 | −33 |
| 39 | ♂ | 259 | 214 | 1.92 | Cor. sublimate....... | 4 | 2.0760 | + 8 | 1.4695 | −23 |
| 40 | ♂ | 177 | 195 | 1.83 | Cor. sublimate....... | 20 | 2.0229 | +11 | 1.4087 | −23 |
| 41 | ♂ | 265 | 216 | 1.92 | Sublimate-formol.... | 4 | 2.3315 | +21 | 1.6565 | −14 |
| 42 | ♂ | 213 | 203 | 1.86 | NaCl + sublimate... | 4 | 1.9927 | + 7 | 1.3947 | −25 |
| 43 | ♀ | 213 | 204 | 1.86 | Tellyesniczky........ | 48 | 1.9643 | + 6 | 1.6372 | −12 |
| 44 | ♀ | 137 | 177 | 1.74 | Tellyesniczky........ | 24 | 1.7981 | + 3 | 1.4906 | −14 |
| 45 | ♂ | 196 | 200 | 1.85 | NaCl + sublimate... | 20 | 2.1549 | +16 | 1.5074 | −19 |
| 46 | ♀ | 135 | 179 | 1.75 | Sublimate-formol.... | 20 | 2.0512 | +17 | 1.3687 | −22 |
| 47 | ♂ | 141 | 179 | 1.75 | Cox (osmic).......... | 48 | 1.9917 | + 2 | 1.5483 | −12 |
| 48 | ♂ | 150 | 182 | 1.76 | Cox (osmic).......... | 72 | 2.1555 | +22 | 1.8365 | + 4 |
| 49 | ♂ | 171 | 192 | 1.81 | Cox (formol-acetic).. | 48 | 1.7687 | − 2 | 1.5003 | −17 |
| 50 | ♂ | 137 | 178 | 1.75 | Cox (formol-acetic).. | 72 | 1.8944 | + 8 | 1.5221 | −13 |

3. A 4 per cent solution of formaldehyde neutralized with $Na_2CO_3$ produces a much greater amount of swelling in the brain of the rat than does a solution that has a faintly acid reaction.

4. A strong neutralized solution of formaldehyde causes a greater percentage weight increase in the rat's brain than does a weak neutralized solution. A reverse result is obtained when the solutions are not neutralized.

5. If rats' brains are subjected to the action of a solution of formaldehyde that is kept at a constant temperature of 36°C., they undergo a greater amount of swelling than is produced when the solution is kept at a temperature of 8 to 11°C. The maximum weight increase in the brains is reached by the end of the first day in the former case, and not until the third day in the latter case.

6. When the conditions under which the solution acts are uniform, the maximum weight increase in rats' brains subjected to the action of a 4 per cent solution of formaldehyde is attained in all cases by the third day, and there is then a gradual decrease in weight. Brains of very young animals tend to reach the maximum earlier than do those of older animals.

7. The percentage weight increase in rats' brains as the result of the action of a 4 per cent formaldehyde solution tends to be greater in the brains of young animals than in those of adults.

TABLE 73

*Percentage weight increase in rats' brains, each kept for ten weeks in 40 cc. of a neutralized solution of 4 per cent formaldehyde made five months before the experiments began (averages for three brains at each age)*

| TIME SOLUTION ACTED | AGE OF RATS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | New-born | 10 days | 20 days | 40 days | 50 days | 70 days | 100 days | 200 days |
| 1 day | 29.7* | 28.8 | 25.0 | 25.2 | 26.9* | 24.5 | 28.3* | 15.3 |
| 3 days | 28.0 | 35.0* | 28.3* | 26.3* | 26.8 | 27.3* | 26.8 | 21.0* |
| 7 days | 27.3 | 33.0 | 27.3 | 25.0 | 25.1 | 25.1 | 25.7 | 18.6 |
| 2 weeks | 23.9 | 31.9 | 27.3 | 24.5 | 25.1 | 25.3 | 26.3 | 18.9 |
| 3 weeks | 23.4 | 31.4 | 28.3 | 24.9 | 25.5 | 24.4 | 25.3 | 19.3 |
| 4 weeks | 22.5 | 30.5 | 26.7 | 24.5 | 24.8 | 25.6 | 26.2 | 19.4 |
| 10 weeks | 17.6 | 27.9 | 26.9 | 24.7 | 25.2 | 25.6 | 25.0 | 19.2 |
| Average percentage gain | 24.6 | 31.2 | 27.1 | 25.0 | 25.6 | 25.4 | 26.2 | 18.8 |

* Maximum weight increase.

TABLE 74

*Percentage weight increase in rats' brains, each kept for ten weeks in 40 cc. of a neutralized solution of 4 per cent formaldehyde made at the time the experiments began (averages for three brains at each age)*

| TIME SOLUTION ACTED | AGE OF RATS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | New-born | 10 days | 20 days | 40 days | 50 days | 70 days | 100 days | 200 days |
| 1 day | 44.4* | 58.2 | 39.5 | 37.9* | 39.3* | 34.4 | 45.6* | 32.4 |
| 3 days | 42.0 | 64.6* | 41.5* | 37.6 | 38.5 | 38.6* | 43.1 | 34.7* |
| 7 days | 41.5 | 62.1 | 40.1 | 36.4 | 35.6 | 34.1 | 41.1 | 30.9 |
| 2 weeks | 38.0 | 62.9 | 39.7 | 35.9 | 36.1 | 34.9 | 41.0 | 30.8 |
| 3 weeks | 37.7 | 63.4 | 40.0 | 35.7 | 36.9 | 34.3 | 40.4 | 31.2 |
| 4 weeks | 36.1 | 62.8 | 39.9 | 35.5 | 35.4 | 35.7 | 40.5 | 31.6 |
| 10 weeks | 33.9 | 61.4 | 39.4 | 35.5 | 36.1 | 35.5 | 37.7 | 31.8 |
| Average percentage gain | 39.1 | 62.2 | 40.0 | 36.4 | 36.7 | 35.4 | 41.3 | 31.9 |

* Maximum weight increase.

8. In animals of the same age the larger brain does not show a greater percentage weight increase after treatment with a solution of formaldehyde than does the smaller one.

9. A 4 per cent solution of formaldehyde extracts solids from the brains of rats of all ages. This is shown by the fact that the percentage

of solids in brains that have been subjected to the action of such a solution is always less than that found in the fresh brains of animals of the same age. Brains of very young rats lose much more of their solids than do brains of older animals.

TABLE 75

*Percentage weight increase in rats' brains, each kept for four weeks in 40 cc. of a neutralized solution of 4 per cent formaldehyde made fresh for each lot of animals killed* (*averages for two brains at each age*)

| TIME SOLUTION ACTED | AGE OF RATS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | New-born | 10 days | 20 days | 40 days | 50 days | 70 days | 100 days | 200 days |
| 1 day | 60.4 | 54.7 | 45.8 | 47.6* | 50.4* | 44.9 | 44.2* | 36.1 |
| 3 days | 65.8* | 58.5* | 52.9* | 47.4 | 47.7 | 48.8* | 42.7 | 40.1* |
| 7 days | 65.4 | 58.5 | 48.3 | 45.6 | 45.1 | 44.2 | 38.3 | 36.2 |
| 2 weeks | 65.1 | 58.4 | 48.9 | 45.3 | 44.8 | 43.2 | 38.6 | 33.0 |
| 3 weeks | 64.8 | 58.2 | 48.9 | 44.7 | 45.2 | 43.9 | 38.8 | 34.7 |
| 4 weeks | 61.7 | 57.8 | 50.4 | 45.1 | 45.4 | 44.9 | 39.3 | 34.9 |
| Average percentage gain | 63.4 | 57.7 | 49.2 | 45.9 | 46.4 | 44.8 | 40.3 | 35.8 |

* Maximum weight increase.

TABLE 76

*Percentage weight increase in rats' brains, each kept for four weeks in 40 cc. of non-neutralized solution of 4 per cent formaldehyde made fresh for each lot of animals killed* (*averages for two brains at each age*)

| TIME SOLUTION ACTED | AGE OF RATS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | New-born | 10 days | 20 days | 40 days | 50 days | 70 days | 100 days | 200 days |
| 1 day | 34.5* | 37.3 | 36.7 | 39.7* | 44.2* | 39.5 | 41.1* | 32.2 |
| 3 days | 18.6 | 45.1* | 45.4* | 39.1 | 42.8 | 42.3* | 39.4 | 35.4* |
| 7 days | 9.9 | 37.8 | 38.2 | 35.6 | 38.1 | 34.3 | 33.8 | 30.2 |
| 2 weeks | 3.5 | 30.4 | 34.6 | 31.5 | 32.6 | 31.5 | 29.0 | 26.7 |
| 3 weeks | 0.4 | 25.9 | 30.7 | 28.3 | 30.6 | 29.5 | 27.4 | 24.5 |
| 4 weeks | −1.5 | 23.5 | 27.9 | 26.6 | 27.8 | 27.3 | 24.3 | 24.5 |
| Average percentage gain | 13.1 | 33.3 | 35.6 | 33.5 | 36.0 | 34.1 | 32.5 | 28.9 |

* Maximum weight increase.

10. Brains of animals infected with pneumonia show a slightly greater percentage weight increase when treated with a 4 per cent solution of formaldehyde than for the brains of healthy animals.

11. Even under the most favorable conditions an aqueous solution of formaldehyde is not a satisfactory fixative for the cell structures in

brain tissues, as it causes a pronounced distention of the nuclei and gives a poor preservation of the nuclear contents.

The more important data are given in tables 73, 74, 75, 76, 77.

TABLE 77

*The percentage of solids in brains of rats of various ages kept from four to eighteen weeks in solutions of 4 per cent formaldehyde (computations made from original brain weights)*

| EXPERIMENTS | AGE OF RATS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | New-born | 10 days | 20 days | 40 days | 50 days | 70 days | 100 days | 200 days |
| Brains kept 18 wks. in neutralized stock solutions. | 8.1 | 10.3 | 14.7 | 18.4 | 19.4 | 19.5 | | 20.9 |
| Brains kept 10 wks. in sol. 5 mos. old | 8.1 | 10.1 | 16.5 | 19.4 | 19.4 | 20.5 | 19.7 | 20.5 |
| Brains kept 10 wks. in freshly made sol. | 7.8 | 10.3 | 16.0 | 19.2 | 19.5 | 20.1 | 20.1 | 21.6 |
| Brains kept 4 wks. in 40 cc. neutral sol. | 8.2 | 10.1 | 16.4 | 19.3 | 19.6 | 19.6 | 20.9 | 21.8 |
| Brains kept 4 wks. in 40 cc. acid sol. | 9.6 | 10.9 | 16.7 | 19.3 | 19.1 | 20.7 | 20.1 | 21.1 |
| Brains kept 4 wks. in 20 cc. neutral sol. | 9.2 | 9.8 | 16.2 | 19.7 | 20.5 | 19.9 | 20.2 | 21.5 |
| Brains kept 4 wks. in 20 cc. acid sol. | 10.5 | 10.9 | 16.3 | 19.0 | 20.0 | 20.1 | 20.8 | 21.6 |
| Brains kept 4 wks. in neutral sol. at temp. 26°C. | 9.7 | 9.8 | 15.1 | 18.7 | 19.4 | 19.8 | 20.1 | 20.1 |
| Brains kept 4 wks. in neutral sol. at temp. 8 to 11°C. | 8.3 | 10.6 | 16.3 | 19.2 | 19.0 | 20.1 | 20.1 | 21.7 |
| Averages for above series. | 8.6 | 10.6 | 16.3 | 19.2 | 19.6 | 20.1 | 20.3 | 21.2 |
| Normal percentage of solids in rats' brains (Donaldson) | 12.2 | 14.6 | 17.5 | 19.5 | 20.9 | 21.1 | 21.3 | 21.6 |
| Percentage loss of solids as result of action of formaldehyde | 29.5 | 29.4 | 7.4 | 1.5 | 6.2 | 4.7 | 4.7 | 1.8 |

*Swelling reactions.* To determine whether slight changes in the composition of the brain could be detected by a swelling reaction, Plant ('19) tested the effect of Müller's fluid (containing 2.5 per cent potassium bichromate plus one per cent sodium sulphate). A brain immersed in this solution not only hardens, but undergoes a regular change in weight and volume. The average percentage gain of each pair of brains in an age group at five intervals up to 75 days is given in table 78.

These data show a rapid increase in weight at seven days, followed by a slow steady loss of such a nature that after 75 days in the fluid the weight of the brain is from 23 to 35 per cent more than when fresh. Age is the main condition which modifies this reaction. The brains of the older rats gain more and retain a greater gain at 75 days. The initial weight of the brain also affects the result, since at like age the lighter brain gains more during the early part of its stay in Müller's fluid, but this difference tends to disappear later.

TABLE 78

*Percentages of gain of pairs of albino rat brains in Müller's fluid arranged according to age and weighed at intervals from twenty-four hours to seventy-five days*

| SEX | AGE | INITIAL WEIGHT | | AVERAGE PERCENTAGES OF GAIN OF BOTH BRAINS IN MÜLLERS FLUID | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 24 hours | 7 days | 14 days | 30 days | 75 days |
| | *days* | *grams* | *grams* | | | | | |
| ♀ | 52 | 1.465 | 1.368 | 19.0 | 28.2 | 26.2 | 23.5 | 22.9 |
| ♀ | 55 | 1.615 | 1.578 | 20.8 | 32.1 | 28.1 | 26.8 | 25.4 |
| ♂ | 57 | 1.757 | 1.671 | 20.6 | 31.2 | 26.0 | 25.9 | 25.7 |
| ♂ | 59 | 1.635 | 1.519 | 21.2 | 33.1 | 29.9 | 27.0 | 26.7 |
| ♂ | 61 | 1.834 | 1.715 | 18.0 | 32.2 | 28.0 | 25.9 | 25.0 |
| ♀ | 61 | 1.699 | 1.581 | 20.0 | 29.5 | 27.3 | 24.1 | 23.0 |
| ♂ | 62 | 1.490 | 1.477 | 18.6 | 31.8 | 28.3 | 25.3 | 24.4 |
| ♂ | 62 | 1.662 | 1.656 | 19.3 | 28.2 | 24.6 | 23.1 | 22.7 |
| ♀ | 62 | 1.497 | 1.496 | 20.5 | 31.7 | 29.1 | 25.7 | 25.3 |
| ♂ | 62 | 1.831 | 1.699 | 20.8 | 32.8 | 30.8 | 28.0 | 27.8 |
| ♀ | 64 | 1.677 | 1.606 | 20.9 | 32.0 | 28.6 | 26.2 | 25.7 |
| ♂ | 67 | 1.651 | 1.587 | 21.7 | 32.6 | 29.7 | 26.6 | 26.4 |
| ♀ | 72 | 1.610 | 1.492 | 27.6 | 33.6 | 30.7 | 27.9 | 26.7 |
| ♂ | 160 | 1.791 | 1.752 | 25.1 | 37.2 | 35.8 | 32.8 | 32.2 |
| ♂ | 218 | 2.008 | 1.824 | 28.3 | 40.0 | 38.6 | 35.7 | 34.6 |

The increase in the weight of the brain is due mainly to the taking up of water, but the percentage of salts deposited in the fixed tissues is much greater than that in the fixing solution. The increase of the myelin with age explains some of the differences here observed.

*Myelin formation.* Using the data in table 74 (Donaldson '15, "The Rat") Sugita ('17) has computed the weight of the dry substance in the brain of the Albino according to brain weight. The relations found are given in the solid graph in chart 13. As this shows, a period of relatively rapid increase in the solids occurs when the brain weight of 0.95 grams is reached and continues up to about 1.35 grams. These brain weights correspond to 11 and 33 days respectively. When a series of albino brains of different ages are extracted with 80 per cent alcohol for 24 hours, followed by 90 per cent alcohol for 24 hours, and the moist brain weight after treatment in deter-

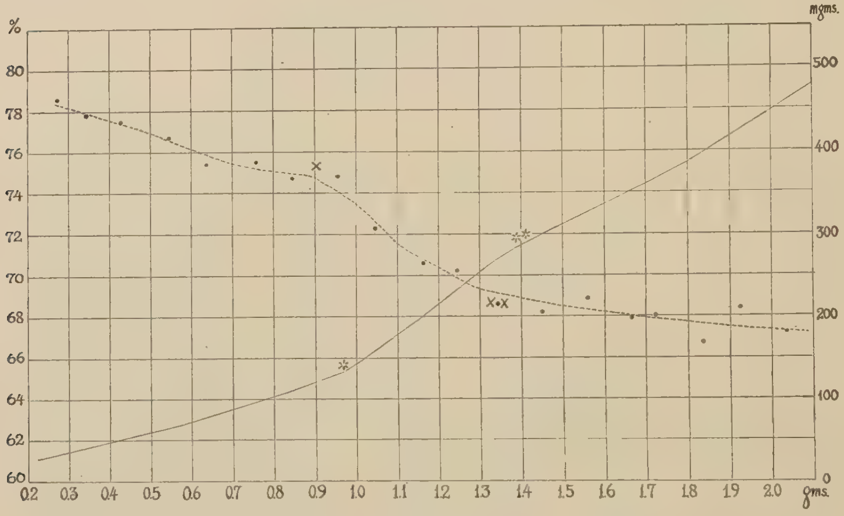

Chart 13 The dotted line shows the ratio between the initial brain weight and the weight after its dehydration and extraction in 80 per cent alcohol (for twenty-four hours) and 90 per cent alcohol (for twenty-four hours) according to a uniform procedure, plotted on the brain weight. The data were taken from table 79. The graph was drawn connecting the middle points of each pair of entries. X and XX indicate the turning points in the graph.

The solid line shows the absolute weight of the solids in the brain according to the brain weight. The data were taken from table 74 in 'The Rat' (Donaldson, '15) and calculated by me. * and ** indicate the turning points in the graph.

For the ratios of brain weight the scale is given on the left side of the chart and for the absolute weight of the solids the scale is given on the right side.

mined, Sugita ('18) finds a progressive loss in weight with advancing age as indicated by the ratio to the initial brain weight —table 79, chart 13. These data show that the period of most rapid extraction approximately coincides with the period of most rapid increase in solids. As the substances extracted are largely the alcohol soluble lipoids, such as appear in the myelin sheaths, it is inferred that the interval between 11 and 33 days is one in which a rapid formation of the myelin sheaths occurs in the brain.

TABLE 79

*Giving for each brain-weight group of the normal albino rat the average initial brain-weight in the fresh condition and the brain weight after dehydration and extraction in 80 per cent alcohol (for twenty-four hours) and 90 per cent (for twenty-four hours) by a uniform procedure. The ratio of the final brain weight to the initial weight is given in the last column as a percentage value. Based on observation on 120 albino rats, sexes combined.*

| BRAIN-WEIGHT GROUP | NUMBER OF CASES | BRAIN WEIGHT WHEN FRESH | BRAIN WEIGHT AFTER DEHYDRATION IN 80 AND 90 PER CENT ALCOHOL | RATIO TO THE INITIAL BRAIN WEIGHT |
|---|---|---|---|---|
| | | *grams* | *grams* | *per cent* |
| II (birth) | 6 | 0.271 | 0.213 | 78.6 |
| III | 8 | 0.343 | 0.267 | 77.8 |
| IV | 9 | 0.428 | 0.332 | 77.5 |
| V | 14 | 0.543 | 0.416 | 76.7 |
| VI | 5 | 0.636 | 0.479 | 75.4 |
| VII | 4 | 0.755 | 0.571 | 75.7 |
| VIII | 10 | 0.844 | 0.630 | 74.7 |
| IX (10 days) | 5 | 0.954 | 0.714 | 74.8 |
| X | 6 | 1.047 | 0.757 | 72.3 |
| XI (20 days) | 5 | 1.161 | 0.820 | 70.6 |
| XII | 5 | 1.245 | 0.874 | 70.2 |
| XIII | 8 | 1.341 | 0.921 | 68.6 |
| XIV | 5 | 1.449 | 0.989 | 68.2 |
| XV | 7 | 1.558 | 1.074 | 68.9 |
| XVI | 8 | 1.667 | 1.131 | 67.9 |
| XVII | 6 | 1.721 | 1.170 | 68.0 |
| XVIII (90 days) | 5 | 1.832 | 1.222 | 66.7 |
| XIX | 1 | 1.924 | 1.317 | 68.4 |
| XX | 3 | 2.037 | 1.369 | 67.2 |

In his studies on myelination in the nervous system of the rat, Watson ('03) found the first evidence of myelin formation shortly after birth—in the cervical region of the spinal cord. Myelin sheaths appear next in the cerebellum and finally in the cerebrum at about 11 days. His results are given in tabular form in table 79 a. It may be noted that the beginnings of myelination in the cerebrum as determined histologically, coincide with the beginning of the rapid increase in solids determined in other ways.

TABLE 79A

*Order of myelination in the nervous system of the rat—Watson ('03)*

| DIVISIONS | MYELINATION BEGINS: | | | RAPIDITY OF MYELINATION PROCESS |
|---|---|---|---|---|
| | Cervical region | Thoracic region | Lumbar region | |
| Spinal cord | | | | |
| | *days* | *days* | *days* | |
| Funiculus ventralis | 2 | 3 | 3 | Rapid |
| Funiculus lateralis | 2 | 3 | 3–6 | Rapid |
| Ventral roots | | | | |
| Extra medullary | 2 | 3 | 3 | Very rapid |
| Intra medullary | 8 | 8 | 8 | Rapid |
| Funiculus dorsalis | | | | |
| Fasiculus cuneatus | 3 | 3 | 4–6 | Rapid |
| Fasiculus gracilis | 4–6 | 3 | 6 | Slow |
| Pyramidal tract | 6 | 10 | 11 | Very slow |
| Dorsal roots | | | | |
| Extra medullary | 3 | 3 | 4–6 | Slow |
| Intra medullary | 8 | 8 | 8 | Slow |

| Cerebellum | MYELINATION BEGINS: | |
|---|---|---|
| | *days* | |
| In stem of central white substance | 8 | Development more rapid than in the cerebrum |
| In laminae: Caudal and Dorsal | 11 | At 15, 16 and 17 days fibers reach the granular layer |
| In laminae : Cephalic | 13 | |
| In laminae : Lobus noduli | 14 | |

TABLE 79A—*Continued*

*Order of myelination in the nervous system of the rat—Watson ('03)*

Cerebrum

| | MYELINATION BEGINS: | |
|---|---|---|
| | *days* | |
| Capsula externa | 11 | Rapid |
| Fibrae longitudinales dorsales | 13 | Slow |
| Stria olfactoria lateralis | 14 | Very rapid |
| Corpus striatum | 14 | Rapid |
| Corpus callosum | 14 | Very slow until after the 24th day |
| Radiations into the cortex | 14 | Development extremely slow |
| Commissura anterior | 17 | Very slow until after the 24th day |
| Thalamus | 17 | Slow |
| Zonal layer | (?) (but certainly not before the 42nd day) | |

7. *Sense organs. Eye.* Collins ('22) has given a few measurements on the eyeball, cornea and the lens of the rat—table 80.

TABLE 80

*Measurements on the eye*

| | DIAMETERS IN MILLIMETERS | |
|---|---|---|
| | Antero-posterior | Lateral |
| Eyeball | 5.5 | 5.5 |
| | Lateral | Vertical |
| Cornea | 5.0 | 5.0 |
| | Antero-posterior | Lateral |
| Lens | 4.0 | 4.5 |

TABLE 81

*Common rat—mature cochlea*

| NUMBER OF TURNS IN COCHLEA | SLANT HEIGHT OF COCHLEA | DIAMETER OF SECOND WHORL | DIAMETER OF LOWEST WHORL | MAJOR AXIS OF OVAL WINDOW | LONGEST DIAMETER OF VESTIBULE | EXTREME LENGTH OF LABYRINTH |
|---|---|---|---|---|---|---|
| | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| 2¼ | 2.75 | 1.75 | 2.5 | 1.0 | 2.0 | 5.25 |

TABLE 82

*Summary table giving the fundamental measurements. The values are in micra, usually rounded, except in one instance where they are in degrees—Wada ('23)*

| Age in days | | 1 | 3 | 6 | 9 | 12 | 15 | 20 | 100 | 546 |
|---|---|---|---|---|---|---|---|---|---|---|
| Body weight, grams | | 5 | 8 | 11 | 10 | 13 | 13 | 29 | 112 | 255 |
| Body length, mm | | 48 | 56 | 63 | 58 | 70 | 75 | 95 | 159 | 213 |
| Radal distance between spiral ligaments—μ (table 2) | *a* I–II | 1410 | 1560 | 1650 | 1635 | 1640 | 1655 | 1645 | 1663 | 1680 |
| | *b* III–IV | 925 | 1025 | 1175 | 1225 | 1233 | 1235 | 1250 | 1270 | 1265 |
| | Average | 1168 | 1293 | 1413 | 1430 | 1437 | 1445 | 1448 | 1467 | 1473 |
| Radial distance between labium vestibulare and habenula perforata | | 115 | 114 | 115 | 118 | 117 | 122 | 122 | 122 | 119 |
| Breadth of membrana basilaris (table 9) | Inner zone | 49 | 63 | 77 | 79 | 88 | 87 | 86 | 92 | 94 |
| | Outer zone | 75 | 91 | 105 | 111 | 100 | 102 | 106 | 106 | 113 |
| | Total | 124 | 154 | 182 | 190 | 188 | 189 | 193 | 198 | 207 |
| Breadth of membrana tectoria (table 4) | Inner zone | 37 | 94 | 105 | 123 | 126 | 124 | 129 | 132 | 133 |
| | Outer zone | 140 | 134 | 154 | 158 | 157 | 160 | 162 | 162 | 163 |
| | Total | 177 | 228 | 259 | 281 | 283 | 284 | 291 | 294 | 295 |
| Thickness (table 4) | | 12 | 32 | 32 | 27 | 25 | 28 | 38 | 36 | 34 |
| Distance from hab. perf. to foot of inner pillar (table 15) | | 22 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| From hab. perf. to outer corner of inner pillar | | 30 | 38 | 43 | 42 | 22 | 18 | 15 | 14 | 15 |
| Distance between the inner and outer pillars | | 10 | 12 | 18 | 18 | 42 | 48 | 58 | 63 | 63 |
| Distance from hab. perf. to the inner corner of the outer pillar | | 40 | 50 | 61 | 60 | 63 | 67 | 72 | 77 | 78 |
| Basal width of inner pillar (table 19) | | — | — | 29 | 31 | 21 | 19 | 15 | 14 | 15 |
| Basal width of outer pillar (table 29) | | — | — | 14 | 18 | 21 | 20 | 14 | 15 | 16 |
| Greatest height of greater epithelial ridge (table 38) | | 66 | 53 | 40 | 40 | 45 | 50 | 58 | 55 | 53 |
| Height from basal plane to surface of pillar cells (table 46) | | 37 | 29 | 30 | 34 | 47 | 51 | 62 | 60 | 59 |
| Length of inner pillar without head (table 61) | | 29 | 25 | 36 | 39 | 40 | 43 | 52 | 49 | 49 |
| Length of outer pillar without head (table 61) | | 28 | 23 | 31 | 34 | 51 | 54 | 62 | 59 | 59 |
| Height of tunnel of Corti (table 49) | | — | — | — | — | 35 | 38 | 47 | 47 | 44 |
| Length of inner hair cells | | 26 | 24 | 27 | 30 | 33 | 33 | 31 | 28 | 29 |
| Diameters of nuclei (table 68) | | 8.1 | 8.3 | 8.3 | 8.5 | 7.7 | 7.6 | 7.4 | 7.0 | 6.6 |
| Length of outer hair cells | | 19 | 18 | 22 | 22 | 23 | 26 | 26 | 26 | 26 |
| Diameters of nuclei (table 68) | | 7.8 | 8.2 | 8.1 | 8.1 | 6.9 | 6.9 | 6.8 | 6.2 | 6.2 |
| Height of papilla spiralis at third series of outer hair cells (table 52) | | 34 | 24 | 24 | 28 | 50 | 58 | 69 | 67 | 64 |
| Total length of Deiters' cells (table 89) | | 27 | 26 | 32 | 36 | 61 | 66 | 72 | 75 | 78 |
| Height of Hensen's supporting cells (table 55) | | 35 | 21 | 20 | 23 | 51 | 60 | 75 | 83 | 86 |
| Angle of lam. retic. with membr. basil. in degrees (table 58) | | — | — | — | — | 10 | 13 | 13 | 15 | 17 |
| Spiral ganglion (table 95) | | | | | | | | | | |
| Diameter—cells | | 10.5 | 11.5 | 12.9 | 13.6 | 13.8 | 14.9 | 18.1 | 16.9 | 16.9 |
| Diameter—nuclei | | 7.9 | 8.0 | 8.4 | 8.5 | 8.5 | 8.7 | 10.2 | 9.5 | 9.4 |
| Vestibular ganglion (table 115) | | | | | | | | | | |
| Diameter—cells | | 20.3 | 22.9 | 23.0 | 23.9 | 23.9 | 23.9 | 24.1 | 24.7 | 25.3 |
| Diameter—nuclei | | 11.7 | 12.0 | 11.9 | 12.0 | 12.1 | 12.0 | 11.9 | 12.3 | 12.2 |

The length, weight or age of the animals used are not given—the significance of the measurements therefore lies in the relations which are shown, rather than in the absolute values, though these probably apply to a full grown animal.

*Ear.* Gray ('07) gives the measurements on the mature cochlea as in table 81.

Wada ('23) has made an elaborate study of the growth of the cochlea at nine ages from birth to middle life. A summary of the fundamental measurements is given in table 82. In this summary the tables referred to are those in the original Memoir.

Wada found one rat in a litter of five which responded to auditory stimuli at nine days. The tunnel of Corti in this rat was open, while in the non-hearing litter mate, it was closed. The cell bodies in the ganglion spirale were still much below the size which they finally attain—see table 82.

TABLE 83

*Area of skin in albino rat—Hill and Hill ('13)*

| BODY WEIGHT = $W$. | AREA OF SKIN = $S$. | $S/W^{2/3}$ |
|---|---|---|
| *grams* | *cm.*$^2$ | |
| 50.5 | 131.0 | 9.60 |
| 62.0 | 162.5 | 10.37 |
| 76.0 | 171.5 | 9.56 |
| 82 0 | 194.0 | 10.27 |
| 129.0 | 251.0 | 9.86 |

8. *Integument.* Myers ('21) reports as follows:

> The deposit of the subcutaneous fat is most marked in the neighborhood of the milk ducts—formed and prospective. From birth to ten weeks of age, the subcutaneous fat is distributed in the same manner in both male and female rats. We believe the deposit serves as a protection against cold and as a reserve food supply. The absence in the rat of a uniformly distributed layer of protective fat may be related to the early development of hair and to the habit of living in closed spaces. In rats underfed from birth, the deposit of subcutaneous fat becomes scanty, and the development of the milk ducts is retarded.

The absolute area of the skin has been measured in square centimeters by Hill and Hill ('13) in five rats. The values are given in table 83.

The area of skin divided by (body weight, grams)$^{\frac{2}{3}}$ gives values ranging from 9.56–10.37 with a mean of 9.93. The authors conclude that the area of skin in square centimeters may be expressed approximately by (body weight, grams)$^{\frac{2}{3}}$ × 10.

*Hair.* The arrangement of the hairs is reported by E. C. Greene ('24 MS.) as follows:

The hairs on the albino rat, over the greater part of the body, are arranged in groups of nine, made up of three small groups in a row, each containing three hairs growing very close together. One hair of the middle group is coarse and corresponds to the spine in related forms. The others are fine. The hair pattern shows parallel rows with the groups of one row alternating with the groups of the next row.

In the region of the upper lip and nose the bristles are developed as long vibrissae, growing in five or six parallel rows running from the nose backwards along the upper lip. The number in a row varied from five to ten. Some of the vibrissae are longer than the whole head of the animal.

In addition to the vibrissae in the region of the nose, there are a few others, usually three just above the eye, another slightly posterior and a little below the outer corner of the eye, and two more near the corner of the mouth.

The eyelashes are very fine and short.

The palms and soles are devoid of hair but the backs of the paws are sparsely covered with short thin hair.

The hairs on the tail are reduced to three rather short bristles emerging from under the edge of each scale.

On the tip of the scrotal sac the hair is sparse and fine.

The scales on the tail are arranged in rings and of these there may be as many as 260 in large specimens. Sweat glands are present on the soles and palms—Römer (96).

9. *Thoracic and abdominal viscera.* For the combined weights of the several viscera see tables 153–156 and chart 49 (Nos. 1–21).

*Gastro-intestinal system.* In the rat both the tonsils and the gall bladder are absent. The volumes of the liver and the pancreas cells, with those of their respective nuclei, have been determined by Morgulis ('11). The organs were fixed in Zenker's solution and imbedded in paraffin and were taken from one normal Albino—110 days old; body length 176 mm., body weight, 137.7 grams—table 84.

TABLE 84

| NUMBER OF MEASUREMENTS OF CELLS | VOLUME IN $\mu^3$ OF | | NUMBER OF MEASUREMENTS OF NUCLEUS | DIAMETERS OF NUCLEUS IN $\mu$ |
|---|---|---|---|---|
| | Entire cell | Nucleus | | |
| | | *Liver cells* | | |
| 100............ | 5075 | 247 2 | 50 | 7.56 × 8.25 |
| | | *Pancreas cells* | | |
| 100............ | 1829 | 94.3 | 40 | 5.48 × 6.00 |

TABLE 85

*Volumetric data for the kidney of the albino rat at various ages. Zenker fixation; Paraffin imbedding; Stain, haematoxylin and eosin*

| SEX | AGE | GROSS BODY WEIGHT | WEIGHT OF ONE KIDNEY | VOLUME OF MEDULLA IN ONE KIDNEY | VOLUME OF CORTEX IN ONE KIDNEY | TOTAL NUMBER OF RENAL CORPUSCLES IN ONE KIDNEY | AVERAGE DIAMETER OF CORPUSCLES |
|---|---|---|---|---|---|---|---|
| | *days* | *grams* | *grams* | *cu. mm.* | *cu. mm.* | | *micra* |
| F. | Newborn | 5.2 | 0.028 | 3.25 | 9.92 | 15,533*<br>10,465† | 62 |
| M. | 7 | 10.3 | 0.078 | 6.57 | 19.13 | 26,598*<br>19,682† | 52 |
| M. | 14 | 11.8 | 0.085 | 14.72 | 29.79 | 24,061 | 53 |
| F. | 21 | 22.6 | 0.145 | 30.59 | 45.76 | 25,930 | 61 |
| M. | 49 | 44.6 | 0.249 | 41.35 | 90.43 | 28,583 | 79 |
| F. | 84 | 122.2 | 0.604 | 106.61 | 219.09 | 28,863 | 95 |
| M. | 245 | 207.0 | 0.783 | 130.26 | 374.44 | 28,000‡ | 127 |

* Including renal corpuscles still in stages of formation.
† Including only fully formed corpuscles.
‡ Estimated approximately from the three preceding cases.

*Pulmonary system.* (See References: also table 146.) Miller ('19) MS. has noted the absence of cartilage in the bronchi of the rat.

10. *Uro-genital system.* See References: also tables 145, 146, 149 and 150.

*Kidneys.* Kittelson ('17) has examined the volumetric relations of the kidney at different ages, and also determined the number of renal corpuscles—table 85.

As the data show, the number of corpuscles increases from birth up to somewhere between three and seven weeks of age, after which it remains fixed—though the kidney may increase greatly in weight after this period.

The volume of the cortex is from 1.5 to 3.0 times that of the medulla, but the combined volume of these two portions represents on the average only about 50 per cent of the volume of the fresh kidney. This indicates that fixation (Zenker's fluid), with subsequent treatment, and exclusion of the capsule and pelvis have greatly reduced the measured volume. The determinations therefore represent relative rather than absolute values.

*Sex organs.* (a) Male. See tables 146, 147, and 149.

(b) Female. See tables 146 and 150.

11. *Exocrine glands.* Myers, 1916–1921, has recorded a number of observations on the structure and arrangement of the mammary glands. There are usually twelve mammary glands, six pairs, designated from the head caudad, as the 1st, 2nd and 3rd thoracic pairs, the abdominal pair and the 1st and 2nd inguinal pairs. Variations in the number of glands occur. There may be only ten or as many as fourteen. After birth there are no external indications in the male of the mammary gland areas. At birth an inguinal and a thoracic fat pad or girdle are clearly marked. These pads are similar in both sexes and are related to the loci of the mammary glands in the female (Myers and Myers, '21). The glands enlarge during the nursing period but shrink after the young are weaned. Immediately after removal of the young the glands enlarge and remain so for forty-eight hours and then return to the virgin size in from two to three weeks (Myers and Myers, '21).

12. *Endocrine system. Percentage of water.* In the normal hypophysis, thyroid and suprarenals Uno ('22) determined the percentages of water, table 86.

*Hypophysis.* Using for fixation the neutral formol—Zenker mixture of Bensley ('11) followed by paraffin imbedding, Addison ('17) has measured the diameters of the several classes of cells in the ventral glandular portion of the hypophysis of normal male albinos at various ages. The results appear in table 87.

In both the acidophile and basophile cells there is seen a cytoplasmic structure adjacent to the nucleus. This is here designted as the *macula*. It is considered by Addison ('16) to be the structure described as the Golgi apparatus. It persists after castration.

TABLE 86

*Percentages of water in the hypophysis, thyroid and suprarenals*

Male rats

| AGE | BODY WEIGHT | PERCENTAGE OF WATER | | |
|---|---|---|---|---|
| | | Hypophysis | Thyroid | Suprarenals |
| *days* | *grams* | *per cent* | *per cent* | *per cent* |
| 148 | 152 | 75.6 | 76.7 | 68.7 |
| 170 | 160 | 76.1 | 76.8 | 68.4 |
| 185 | 186 | 70.3 (?) | 76.8 | 69.7 |

TABLE 87

*Average diameters of cells in ventral glandular portion of hypophyses of normal male albino rats at various ages; average of 10 measurements in each case*

| AGE | ACIDOPHILES | | BASOPHILES | | | RESERVE CELLS |
|---|---|---|---|---|---|---|
| | Cell bodies | Nuclei | Cell bodies | Nuclei | Maculae | Nuclei |
| *months* | μ | μ | μ | μ | μ | μ |
| 2 | 11.5 x 8.0 | 6.3 x 5.2 | 13.5 x 11.5 | 5.8 x 4.8 | 5.5 x 4.0 | 5.9 x 4.6 |
| 3 | 11.1 x 9.3 | 6.4 x 5.3 | 14.0 x 11.0 | 6.7 x 5.0 | 5.5 x 3.8 | 6.3 x 4.4 |
| 4 | 11.3 x 8.0 | 6.4 x 5.5 | 14.5 x 11.0 | 6.7 x 5.6 | 6.0 x 4.3 | 6.4 x 5.0 |
| 6 | 11.4 x 8.4 | 6.5 x 5.1 | 15.5 x 11.3 | 6.8 x 4.7 | 5.4 x 4.3 | 6.3 x 4.9 |
| 8 | 11.2 x 8.2 | 6.8 x 5.8 | 15.9 x 12.4 | 7.1 x 6.0 | 5.7 x 4.5 | 6.5 x 5.4 |

TABLE 88

*Average weights of the glandular and nervous lobes—in albino rats*

| NUMBER OF RATS | SEX | BODY WEIGHT | GLANDULAR (1) | NERVOUS (2) | RATIO OF (2) TO (1) |
|---|---|---|---|---|---|
| | | *grams* | *mgm.* | *mgm.* | |
| 5 | M. | 193 | 4.9 | 1.24 | 4.0 |
| 10 | M. | 229 | 5.6 | 1.24 | 4.5 |
| 5 | F. | 125 | 4.8 | 1.00 | 4.8 |
| 10 | F. | 167 | 6.2 | 1.18 | 5.2 |

*Lobes of hypophysis.* Degener ('22) determined the weights of the lobes of the hypophysis, glandular and nervous, in the fresh state. The data are entered in table 88.

These determinations show that with increasing body weight, within each sex, the glandular lobe increases more rapidly than the nervous. As between the sexes the glandular lobe in the female is relatively larger than in the male.

*Suprarenals.* From the studies of J. C. Donaldson ('19) it appears that the left suprarenal is usually distinctly heavier than the right. The volume of the medulla relative to that of the entire gland decreases rapidly from birth to 50–100 grams of body weight, after which it increases in the male, but remains constant in the female—chart 14.

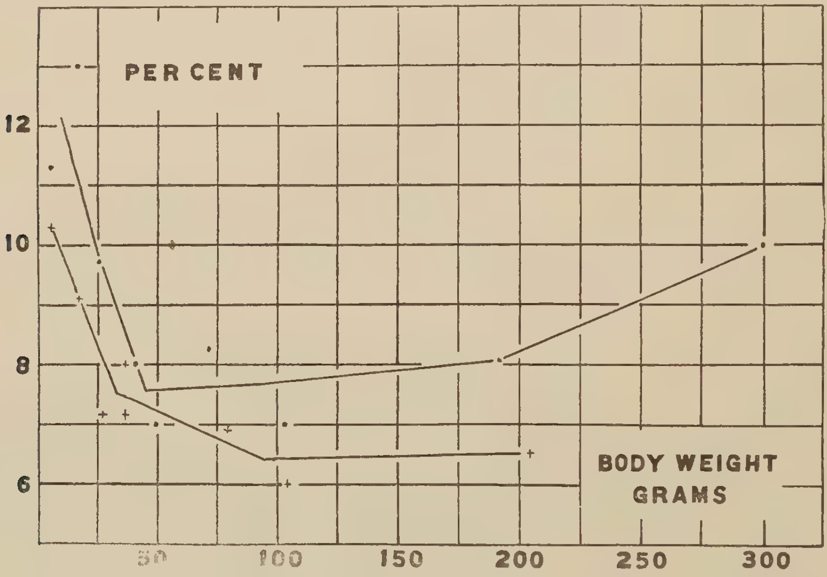

Chart 14 The change in volume of the medulla expressed as a percentage of the whole adrenal gland. Dots, •, males, individual values. Crosses, +, females, individual values.

The greater weight of the suprarenals in the female is therefore due mainly to the greater weight of the cortex.

*Thymus.* See tables 151 and 152.

*Thyroids and parathyroids.* See table 148.

*Pancreas : Islets of Langerhans.* See table 88 a.

A careful study of the number of islets of Langerhans in the pancreas has been made by M. D. Overholser (MS. '24). The

TABLE 88A

*The number of islets of Langerhans in the pancreas of the albino rat—Overholser (MS '24)*

| SEX | WEIGHT | AGE | WEIGHT OF PANCREAS | TOTAL NUMBER OF ISLETS |
|---|---|---|---|---|
| | *grams* | *days* | *grams* | |
| | 4.0 | 1 | | 1,494 |
| ♂ | 4.5 | 4 | 0.015 | 1,575 |
| ♂ | 5.5 | 5 | 0.014 | 1,517 |
| ♂ | 6.0 | 2 | 0.012 | 2,002 |
| ♂ | 8.5 | 2 | 0.018 | 1,995 |
| ♀ | 11.5 | 4 | 0.030 | 2,199 |
| ♀ | 16.0 | 7 | 0.049 | 3,618 |
| ♀ | 17.5 | 14 | 0.035 | 3,417 |
| ♀ | 22.5 | 21 | 0.112 | 3,606 |
| ♀ | 32.5 | 28 | 0.209 | 9,571 |
| ♂ | 33.2 | 21 | 0.115 | 6,089 |
| ♂ | 40.5 | 17 | 0.086 | 12,628 |
| ♂ | 44.0 | 35 | 0.281 | 9,494 |
| ♀ | 48.0 | 24 | 0.275 | 8,530 |
| ♂ | 48.0 | 35 | 0.270 | 2,938 |
| ♀ | 49.0 | 28 | 0.295 | 9,090 |
| ♂ | 50.0 | 28 | 0.213 | 8,693 |
| ♀ | 64.0 | 35 | 0.376 | 9,082 |
| ♀ | 64.0 | 56 | 0.391 | 5,985 |
| ♂ | 64.5 | 49 | 0.388 | 9,784 |
| ♀ | 72.0 | 28 | 0.489 | 9,035 |
| ♀ | 73.0 | 31 | 0.458 | 6,875 |
| ♀ | 88.0 | 63 | 0.628 | 5,282 |
| ♂ | 109.0 | 40 | 0.620 | 14,579 |
| ♂ | 113.5 | 51 | 0.631 | 7,819 |
| ♂ | 115.0 | 85 | 0.558 | 8,750 |
| ♀ | 116.0 | 42 | 0.829 | 6,938 |
| ♀ | 118.0 | 58 | 0.832 | 8,329 |
| ♂ | 142.0 | | 0.697 | 5,727 |
| ♂ | 144.0 | 80 | 0.678 | 11,126 |
| ♀ | 154.0 | | 0.613 | 4,314 |
| ♂ | 164.5 | 70 | 0.599 | 6,461 |
| ♀ | 166.0 | | 0.670 | 10,048 |
| ♂ | 169.0 | 65 | 0.859 | 5,962 |
| ♂ | 173.0 | | 0.572 | 6,009 |
| ♂ | 175.0 | | 0.485 | 8,684 |
| ♂ | 184.0 | | 0.627 | 4,915 |
| ♂ | 189.0 | | 0.639 | 6,636 |
| ♂ | 198.0 | | 0.518 | 5,794 |
| ♀ | 198.0 | | 0.917 | 6,422 |
| ♂ | 216.0 | | 0.742 | 4,548 |
| ♂ | 266.0 | 864 | 0.779 | 7,654 |
| ♂ | 316.0 | | 1.053 | 5,024 |
| ♂ | 364.0 | 901 | 0.949 | 4,595 |

islets were brought into view by the method of injection and his record according to body weight after birth is based on 44 albino rats. The gross results are given in table 88 a. The weight of the pancreas increases with body weight and also tends to be heavier in the female. The absolute number of islets is highly variable yet, in a general way, the number increases rapidly for the first twenty days—the period of dependence on the mother—then reaches and maintains rather a high value for the next thirty days, but later decreases somewhat with advancing body weight and age. There are four instances (three males and one female) of very high numbers of islets, all in animals under 80 days in age and 170 grams in body weight. These instances appear to be individual variations. As the absolute number of islets increases less rapidly than does the weight of the pancreas or that of the entire body, it follows that the islets become relatively less numerous when so compared. The absolute weights of the pancreas are in this series less than those found by Hatai ('18) in table 147, but this difference appears to be due largely to differences in the method of preparation for weighing.

### ANATOMY: REFERENCES

*Anatomy—gross and microscopic.* Akamatsu, '05. Anglas, '10?. Brisson, 1756. Flower, 1872. Goto, '06. Krause, 1876. Leydig, 1854, 1857. Martin and Moale, 1884. Meyer, 1800. Morrell, 1872. Owen, 1868. Rolleston, 1870. Waller, 1693. Wiedersheim, 1897.

*Histology.* Allen, '16, '19. Bell, '11. Bensley, '08. Bullard, '12. Drew, '23. Duesberg, '07. Gage, 1887. Gottlieb, '14. Gulliver, 1839, 1842. Hance, '17. Hartley, '07. Hatai, '02 b. Hoyer, 1890. McMunn, 1884. Macklin and Macklin, '20. Mayer and Schaeffer, '14. Miller, '22. Schäfer, '00. Solger, 1889. Zoja, 1891.

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1883. Giannelli, '11. Grosser, '09. Hoven, '14. Huber, '15, '15 a, '15 b. Klebs, 1891. Lane-Claypon, '07. Melissinos, '07. Robinson, 1892, 1892 b, 1892 c, '04. Ryder, 1888. Schultze, 1897. Selenka, 1883, 1884. Tilney and Casamajor, '17. Warren, '17. Widakowich, '09, '10 a. (*d*) *Later stages.* Addison and How, '21. Addison and Appleton, '22. Adloff, 1898. Askanazy, '08. Braun, 1882. Bremer, '16, '23. Brunn, 1887. Chievitz, 1885, 1890. Debeyre, '00, '04. Freund, 1892. Glas, '04. Gottschau, 1883. Helly, '01. Henneberg, 1899, '00, '05, '08, '14. Heuser, '14. Jordan, '21. Jordan and Helvestine, '23. Kölliker, 1879. Lewis, '15. Maximow, '10. Meyerheim, 1898. Myers, '16, '17, '17 a, '19. Paterson, 1890, '01. Robinson, 1889, 1892 a, 1896. Scammon, '16. Soulié, '03. Stewart, '23. Stotsenburg, '15. Strong, '21. Tandler, '02. Toyofuku, '10. Uskow, 1883. Warren, '15. Weiss, '01. Willach, 1888. Williams, 1896. Zuckerkandl, '03. (*e*) *Monsters.* Conrow, '15, '17, '17 a.

*Bones.* (*a*) *Connective tissue.* Bast, '21. Bignotti, '00. Hyrtl, 1845. Katzenstein, '03. Kohlmeyer, '06. Macklin, '17, '17 a. Morgulia and Gies, 14. Renaut, '04. Retterer, '05. Todd, '23. Weiss, '00. (*b*) *List of bones.* Donaldson and Conrow, '19. (*c*) *First appearance of ossification centers.* Strong '24. (*d*) *Skull measurements.* Donaldson, '12 a. Donaldson and Conrow, '19. Hansemann, '04. Hatai, '07, '07 c. (*e*) *Teeth.* Addison and Appleton, '15, '22. Beretta, '13. Brunn, 1880. Gingery, '23. Hammett and Justice, '23. Jordan, '23. MacGillavry, 1875, 1876. Marshall, '20, '21. Owen, 1840–1845. Terra, '11. Toverud, '23. (*f*) *Displacement of teeth.* Erdheim, '11. Hammett, '22. Wiedersheim, '03. (*g*) *Adipose tissue.* Auerbach, '02. Hammar, 1895. Mietens, '08. Poljakoff, 1888. Rasmussen, '22, '23.

*Muscles.* Alezais, '02. Kolster, '01. Meek, 1899. Morpurgo, '98, '99, '99 a. Rosenfeld, 1899. Stirling, 1883 a.

*Blood vessels and lymphatics.* Ranvier, 1896.

*Blood vessels.* Dreyer, Ray and Walker, '12. Hashimoto, '21. Keith and Flack, '07. Kent, 1893. Lemoine, '06. Meiklejohn, '14. Minot, '00. Tandler, 1899.

*Vascularity of central nervous system.* Craigie, '20, '21, '23.

*Blood.* Addison and Richter, '23. Chisolm, '11. Collip, '20 a, '20 b. Gad-Andersen, '19. Hatai, '18. Jolly and Stini, '05. Kōsaka and Seki, '21. Mattill, '23 a. Sherrington and Copeman, 1893. Zucker and Gutman, '23.

*Percentage of water.* Hatai, '18, '18 b.

*Resistance of red cells.* Takenouchi, '19.

*Refractive index.* Hammett and Teller, '22. Hammett, '23 b. Hatai, '18 b, '21.

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*Haemoglobin.* Abderhalden, '02. Gamgee, 1898. Halliburton, 1888. Preyer, 1866, 1871. Quinquaud, 1873. Reichert and Brown, '09. Schäfer, 1898. Stirling and Brito, 1882. Welker and Williamson, '20.

*Number.* Abderhalden, '02. Addison and Richter, '23 a. Cramer, Drew and Mottram, '22, '23. Geiling and Green, '21. Jencks, '22. Jolly, '06, '09, '19. Murphy and Sturm, '19. Rous and Robertson, '17.

*Size.* Gulliver, 1875. Kanthack and Hardy, 1894. White, '01. Wormley, 1888.

*Blood picture.* Cramer, Drew and Mottram, '21. Cramer, '22. Downey, '17 a. Eyre, '13. Furno, '11. Klieneberger and Carl, '12. Taylor, '16. Wolferth, '17.

*Lymph nodes and hemolymph nodes.* Drummond, '00. Helly, '02. Job, '15, '18, '22. Lewis, '02. Meyer, '13. Rapp, 1839. Vincent, 1897 b. Weidenreich, '02.

*Nervous system.* Craigie, '24. (*a*) *Brain.* Addison, '11. Bradley, '03. Cajal, 1897, '09–'11. Cameron, '04. Craigie, '20, '21, '23. Droogleever Fortuyn, '14. Dunn, '16, '17. Donaldson, '08, '09. Donaldson and Hatai, '11. Edinger, '10, '11. Flatau and Jacobsohn, 1899. Goldstein, '04. Haller, '10. Hatai, '03, '09, '09 a. Held, 1890. Hermanides and Köppen, '03. Johnston, '13, '23. King, J. L., '10. Kōsaka and Hiraiwa, '15. Lapicque, '07. Lewis, 1881. Löwy, '10. Meek, '07. Papez, '23, '23 a, '23 b. Reichardt, '06. Sugita, '18 d. Tilney and Riley, '21. Wagner, 1841. (*b*) *Cell Division.* Allen, '12. Hamilton, '01. (*c*) *Linear dimensions.* Sugita, '17. (*d*) *Growth of callosum.* Suitsu, '20. Zuckerkandl, '09. (*e*) *Growth of cerebral cortex in thickness.* Sugita, '17 a. (*f*) *Number of cells in cerebral cortex—computed.* Sugita, '18 b. (*g*) *Growth in the diameters of cortical cells with their nuclei.* Sugita, '18 c, '18 e. (*h*) *Olfactory bulbs—number of cells.* Holt, '17.

*Spinal cord.* Allen, '12. Bardeleben, 1899. Bechterew, 1890. Bregmann, '15. Bullard, '12. Hamilton, '01. Lenhossek, 1889. Pontier and Gérard, '00. Ranson, '13, '14 a. Retzius, 1893. Robinson, 1892 a. Spitzka, 1886. Sterzi, '04. Stieda, 1869. Van der Vloet, '06.

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*Technical methods.* Cajal, 1889, '03. King, '10, '13 a. Ohlmacher, 1897. Turner, '04.

*Swelling reactions.* Plant, '19.

*Myelin formation.* Donaldson, '15. Sugita, '17, '18. Watson, '03.

*Sense organs.* Anderson, 1893. Asai, '08. Bulle, 1887. Collins, '22. Ebner, 1873. Gmelin, 1892. Gray, '07, '08. Greeff, '00. Hönigschmied, 1873. Koganei, 1885. Lauber, '01. Lovén, 1868. Mayer, 1843. Münch, 1896. Schäfer, '00 a. Stahr, '03. Tello, '06. Tuckerman, 1892. Wada, '23. Wyss, 1870.

*Integument.* Calef, '00. Durham, '04. Hill and Hill, '13. Myers and Myers, '21. Römer, 1896. Spain, '15.

*Gastro-intestinal tract* (including pancreas and liver). Asher, ’03, ’08. Berry, ’01. Brümmer, 1876. Bujard, ’05, ’08, ’09. Custor, 1873. Cuvier, 1805. Demjanenko, ’09. Edelmann, 1889. Ellenberger and Guenther, ’08. Frenkel, 1892. Gillette, 1872. Hilton, ’02. Home, 1807. Klein and Verson, 1871. Kupffer, 1876. Langley, 1882. Mann, Brimhall and Foster, ’20. Mann, ’20. Mazzarelli, 1890. Morgulis, ’11. Mouret, 1895. Müller, 1830. Nicolas, 1890. Oppel, 1896–1914. Podwyssozki, 1878. Ranvier, 1883, 1884, 1885, 1886. Retzius, 1841. Rubeli, 1890. Salter, 1859. Saviotti, 1869. Schmidt, 1863. Schwalbe, 1872. Severin, 1885. Stevenson, ’21. Toepfer and Fleischmann, 1891. Watney, 1874. Zillinberg-Paul, ’09.

*Pulmonary system.* Arnstein, 1877. Frankenhaeuser, 1879. Fuchs-Wolfring, 1898. Gegenbaur, 1892. Guieysse, 1898. Hansemann, 1895. Klein, 1875. Linser, ’00. Livini, 1896. Miller, 1893. Schulze, 1871. Stewart, ’23. Zumstein, 1890.

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*Exocrine glands.* Asp, 1873. Castellant, 1898. Falcone, 1898. DaFano, ’22. Garnier, 1897. Giannelli, ’14. Loewenthal, 1894, 1894 a, ’00, ’08. Myers, ’16, ’17, ’17 a, ’19, ’19 a, ’19 b. Myers and Myers, ’21, ’21 a. Mayer, 1894. Peters, 1890. Ranvier, 1886 a. Schickele, 1899. Smith, ’20. Sutter, ’19. Zumstein, 1891.

*Endocrine system* (See also Endocrine System under “Physiology”). (*a*) *General—Percentage of water.* Uno, ’22. (*b*) *Hypophysis.* Addison, ’16, ’17. Degener, ’22. Dostoiewsky, 1886. Bensley, ’11. Gemelli, ’05, ’06 a. Gemelli, E. ’03. Gentes, ’03. Retzius, 1894. Stendell, ’13, ’14. ’Tilney, ’11, ’13. (*c*) *Suprarenals.* Bonnamour, ’05. Cartier, 1890–1895, Dewitzky, ’12. Donaldson, J. C., ’19. Dostoiewsky, 1886 a. Elliot and Tuckett, ’06. Jackson, ’19. Lewis, ’23. Ogata and Ogata, ’17. Vincent, ’10. Watson, ’07. (*d*) *Thymus.* Hatai, ’14 a. Hewer, ’16. Pappenheimer, ’13. Salkind, ’15. (*e*) *Thyroid and Parathyroids.* Chandler, ’23. Douglas, ’15. Erdheim, ’06. Hoskins, ’23. Watson, ’09. (*f*) *Pancreas: Islets of Langerhans.* Overholser, MS. ’24.

# CHAPTER 4

# PHYSIOLOGY

1. The rat compared with man (a) Technique. 2. Muscles and nerves. 3. Nervous system. 4. Special senses. 5. Circulation. 6. Blood and lymph. 7. Respiration. 8. Metabolism. 9. Nutrition (a) Tests, (b) Effects on systems and functions, (c) Body temperature, (d) Calorimetry. 10. Reproduction and the sex organs. 11. Exocrine system: General. 12. Endocrine system. 13. Pineal gland. 14. Hypophysis. 15. Feeding endocrine glands.

1. *The rat compared with man.* In order to have a background for the interpretation of the physiological responses of the rat, it is desirable to indicate its relations to man. If the data for the relative weights of the different systems in the man (69.7 kilos) Bischoff ('63) are compared with those of the one year old rat (Jackson and Lowrey, '12) the relations are as in table 89.

Table 89 shows that in man the skeleton is relatively heavy. The small weight of the skin depends in part on the relative diminution of the surface area in the larger animal, man—a factor which tends to reduce the relative weight of the skin. The massive fat was weighed as one part, in the case of man, but not similarly handled in the case of the rat. Allowing for all of these differences, there remains a fair correspondence between the two forms in the proportionate weights of the musculature and the viscera.

In the case of the viscera, however, the individual organs do not stand in the same relations. I have sought to illustrate this by the data presented in table 90. Here the weights of several organs taken from the tables for the rat, tables 144, 145, 146 and 148, are transformed into those to be expected in a man of 65 kilos, if the percentage relations were those in the rat. These computations are controlled by the data for the observed weights in man, obtained from various sources.

In this comparison it appears that in man the lungs, heart, brain, spleen and thyroid are heavier, while the remaining organs are lighter:—the most striking differences from the computed values being shown by the heavier thyroid, brain and lungs, and the lighter eyes. While the differences thus revealed are of interest, the greater significance is to be attached to the general similarities of the two forms.

TABLE 89

*Percentage weight of systems in man and albino rat*

| | MAN, ♂ 69.7 KILOS | ALBINO RAT, ♂ ♀ 234.6 GRAMS |
|---|---|---|
| | *per cent* | *per cent* |
| Skeleton | 15.9 | 10.9 |
| Musculature | 41.8 | 45.4 |
| Viscera | 10.8 | 13.3 |
| Skin | 6.9 | 18.0 |
| Fat | 18.2 | — |
| Remainder | 6.4 | 12.4 |
| | 100.0 | 100.0 |

*Equivalent ages.* It has already been stated that post natal growth of the rat is about thirty times as rapid as that of man, and it is conspicuously true that in the growing nervous system the degree of development attained in the rat at a given age is also attained by man when thirty times as old.

TABLE 90

*Weights of the organs in the rat compared with man*

| ORGAN | RAT 300 GRAMS, MALE | COMPUTED FOR MAN 65 KILOS, MALE | OBSERVED MAN | |
|---|---|---|---|---|
| | *grams* | *grams* | *grams* | |
| Liver | 13.7 × 217 = | 2972.9 | *1800* | Hoffman |
| Kidneys (2) | 2.5 × 217 = | 542.5 | *400* | Hoffman |
| Heart | 1.1 × 217 = | 238.7 | 350 | Hoffman |
| Spleen | 0.79 × 217 = | 171.4 | 220 | Hoffman |
| Thyroid | 0.044 × 217 = | 9.5 | 35 | Piersol |
| Suprarenals (2) | 0.045 × 217 = | 9.8 | *7.4* | Vierordt |
| Lungs | 1.7 × 217 = | 368.9 | 995 | Vierordt |
| Eyes | 0.33 × 217 = | 71.6 | *13.5* | Vierordt |
| Brain | 2.00 × 217 = | 434.0 | 1430 | Vierordt |

In the span of life, however, some of the major events are differently spaced. Thus suckling continues in the rat for 20–25 days, equivalent to 20–25 months in man, and puberty may occur in the rat at 50 days or later, which corresponds to 50 months, a little over four years in man.

Hatai ('17) has shown that at equivalent ages the general composition of the body in terms of water, solids, protein, fat and ash is similar in man and several other mammals.

The results serve to emphasize the well recognized similarity among mammals as a group.

(*a*) *Technique.* Concerning the acuteness of sensation in the rat our information is meagre. The response to some sensory stimuli, especially to sounds, is very marked—as is shown by jumping when the hands are clapped, and in some cases by an almost maniacal running and jumping—going on to exhaustion—when a bundle of keys is jingled before a cage. Vision in the albino is poor as compared with the strains having pigmented eyes. It also seems sensitive to vibration.

The emotional states of the rat are very important and play a leading rôle. There is therefore a profound difference in general condition between rats that are wild and in fear and those that are tame and gentle.

If rats are played with every day and handled, they soon come to enjoy the experience, and not only do not offer to bite, but relax when picked up, and lose all tendency to struggle in the hand. Fear and flight reactions completely disappear and the general condition of such rats differs widely, even from those that are moderately tame and can be handled without danger of their biting. Thus Hammett, ('21 i) found that when rats of this half tame group were used for removal of the thyroid apparatus, the mortality was 79 per cent, while the same operation could be made on thoroughly gentle rats, which had been handled for weeks before the event, with a mortality of only 13 per cent. Moreover, when wild Norways were used, the mortality was 90 per cent, Hammett ('22).

It is inferred from this that the best results will be obtained from operations when these are made on thoroughly tame and gentle rats. Further, it is highly probable that all physiological responses are definitely modified by the emotional state of the rat.

2. *Muscles and nerves.* The rate of movement in flight (Dubois, '98), for example, may be due in a measure to the short nerves, or the rapidity of metabolic change in muscles, or to both.

When the gastric end of a duodenal segment is taken some fifteen hours after the last feeding from a healthy male rat 80–200 days of age, and when the animal has been for at least three days in the transfer cage, and is also carefully handled and anaesthetized without undue excitement, the response of the segment to sodium carbonate solution is fairly regular (Hatai and Hammett, '20). Segments from females should not be used.

TABLE 91

*Showing the content of total nitrogen as well as non-protein nitrogen in the entire brain of the albino rat at different ages*

| (a) BODY WEIGHT | (b) BRAIN WEIGHT | (c) WATER IN BRAIN | (d) SOLIDS | (e) TOTAL NITROGEN IN ENTIRE BRAIN | (f) NON-PROTEIN NITROGEN IN ENTIRE BRAIN | (g) TOTAL NITROGEN TO SOLIDS | (h) NON-PROTEIN NITROGEN TO TOTAL NITROGEN | (i) NON-PROTEIN NITROGEN PER GRAM OF SOLIDS | (j) MEAN AGE | (k) NUMBER OF RATS USED |
|---|---|---|---|---|---|---|---|---|---|---|
| *grams* | *grams* | *per cent* | *grams* | *mgm.* | *mgm.* | *per cent* | *per cent* | *mgm.* | *days* | |
| 4.8 | 0.231 | 88.30 | 0.027 | 3.07 | 0.38 | 11.40 | 12.33 | 14.1 | 1 | 45 |
| 7.1 | 0.459 | 88.75 | 0.052 | 5.73 | 0.71 | 11.08 | 12.38 | 13.7 | 5 | 32 |
| 9.5 | 0.598 | 88.13 | 0.071 | 7.70 | 0.91 | 10.86 | 11.81 | 12.8 | 7 | 17 |
| 17.9 | 1.175 | 84.90 | 0.177 | 18.28 | 1.63 | 10.30 | 8.89 | 9.2 | 15 | 12 |
| 26.7 | 1.284 | 80.86 | 0.246 | 23.70 | 2.11 | 9.65 | 8.91 | 8.6 | 24 | 6 |
| 34.8 | 1.379 | 80.26 | 0.272 | 26.21 | 2.22 | 9.63 | 8.48 | 8.2 | 35 | 6 |
| 66.6 | 1.508 | 79.58 | 0.308 | 28.00 | 2.42 | 9.09 | 8.64 | 7.9 | 54 | 6 |
| 156.6 | 1.762 | 78.89 | 0.372 | 33.72 | 2.63 | 9.07 | 7.81 | 7.1 | 116 | 6 |
| 161.4 | 1.803 | 78.43 | 0.389 | 34.13 | 2.59 | 8.78 | 7.58 | 6.7 | 274 | 6 |
| 185.5 | 1.858 | 78.00 | 0.409 | 35.94 | 2.89 | 8.79 | 8.04 | 7.1 | 382 | 6 |

Working with duodenal segments thus standardized, Hammett ('21a) found that in response to the stimulation by 0.1 M sodium carbonate, the segment gave nearly uniform contractions. In 66 per cent of the observations the deviation was plus or minus 5 per cent, and in 90 per cent of the observations, plus or minus 10 per cent.

Hammett ('21 b) concludes that the intestinal mechanism primarily stimulated when sodium carbonate is thus applied to the isolated duodenal segment of the rat is neural and not muscular; and in the unexcited male it is through a mechanism mediated by the vagus, while in the excited rat the effect is produced through splanchnic endings or fibers.

*Exercise.* See Chapter 1, page 16.

3. *Nervous system.* (*a*) *Central.* In a study of the metabolic activity of the nervous system Hatai ('17 a) determined the amount of non-protein nitrogen in the brain under normal conditions. The data appear in table 91 and chart 15.

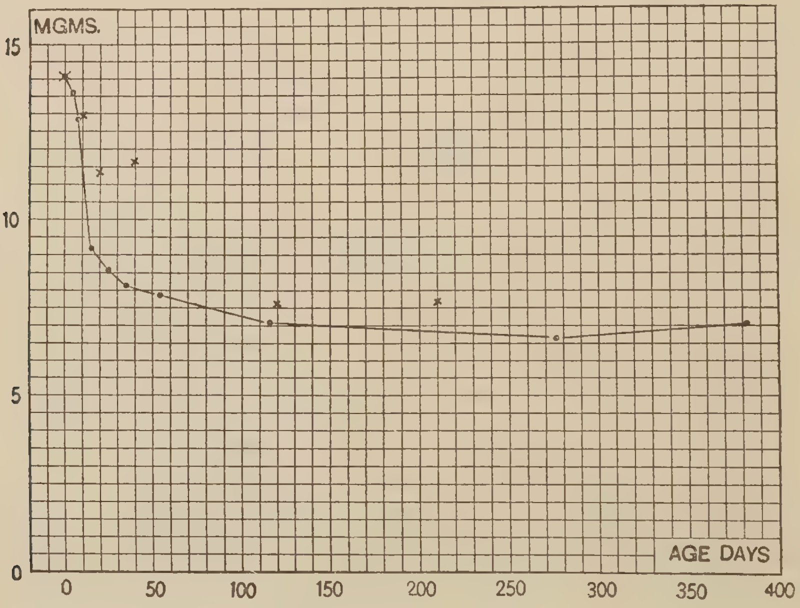

Chart 15 Showing the number of milligrams of non-protein nitrogen per gram of the dried brain at different ages. The chart shows also the proportional value of organic extractives together with inorganic salts in the brain of the albino rat, as determined by W. Koch and M. L. Koch ('13). •—• Non-protein nitrogen; × organic extractives and inorganic salts.

The number of milligrams of non-protein nitrogen per gram of total solids decreases rapidly during the first 15 days, and less rapidly up to 120 days, after which age it remains nearly constant. This apparent decrease is largely due to the formation of myelin. When determined in relation to the lipoid-free solids, the percentage of nitrogen is the same in the several parts of the brain and in the spinal cord.

Hatai concludes that the nitrogenous organic extractives are intimately related to the active cell substance and that the protein fraction of the brain is well saturated with metabolic products.

TABLE 92

*Showing the total nitrogen as well as non-protein nitrogen in several organs of the adult albino rat*

| | TOTAL NITROGEN IN FRESH TISSUE | NON-PROTEIN NITROGEN PER 100 GRAMS FRESH TISSUE | NON-PROTEIN NITROGEN TO TOTAL NITROGEN | AGE |
|---|---|---|---|---|
| | *per cent* | *mgm.* | *per cent* | *days* |
| Brain | 1.953 | 159 | 8.168 | 143 |
| Testes | 1.729 | 170 | 9.806 | 143 |
| Liver | 3.435 | 182 | 5.332 | 143 |
| Kidneys | 3.243 | 229 | 7.572 | 143 |
| Blood | 3.093 | 35 | 1.134 | 241 |

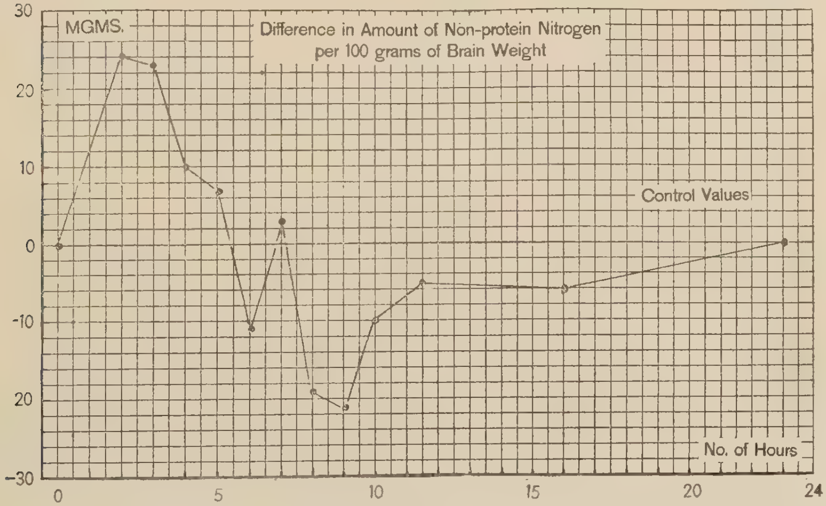

Chart 16 Showing the differences in the amount of non-protein nitrogen in the brain of test rats from that found in the controls.

For comparison, the total nitrogen and non-protein nitrogen in several organs are given in table 92.

The amount of non-protein nitrogen in the brain at intervals during twenty-four hours after feeding, has been determined by Komine ('19). Albinos of both sexes and more than 100 days old were used—table 93 and chart 16.

TABLE 93

*Showing the data on the amount of non-protein nitrogen of the brain, together with several other observations during twenty-four hours after feeding*

Controls A

| BODY WEIGHT | AGE | NUMBER RATS USED | BRAIN WEIGHT | WATER IN BRAIN | TOTAL NITROGEN IN BRAIN | NON-PROTEIN NITROGEN IN TOTAL NITROGEN | NON-PROTEIN NITROGEN PER 100 GRAMS BRAIN | DIFFERENCE |
|---|---|---|---|---|---|---|---|---|
| *grams* | *days* | | *grams* | *per cent* | *per cent* | | *mgms.* | |
| 66.8 | 123 | 2 | 1.519 | 78.6 | 2.11 | 2.57 | 156 | 24 |
| 66.8 | 120 | 3 | 1.519 | 78.6 | 2.11 | 2.37 | 157 | 23 |
| 70.0 | 118 | 5 | 1.508 | 78.6 | 2.12 | 2.52 | 165 | 10 |
| 74.4 | 131 | 6 | 1.514 | 78.3 | 2.09 | 2.40 | 162 | 7 |
| 92.2 | 135 | 4 | 1.585 | 78.7 | 2.08 | 2.34 | 150 | −11 |
| 96.3 | 135 | 6 | 1.590 | 77.9 | 2.09 | 2.33 | 148 | 3 |
| 98.6 | 112 | 3 | 1.573 | 78.7 | 2.13 | 2.36 | 152 | −19 |
| 97.3 | 123 | 2 | 1.608 | 79.6 | 2.06 | 2.53 | 149 | −21 |
| 99.6 | 161 | 3 | 1.611 | 78.4 | 2.11 | 2.57 | 163 | −10 |
| 106.7 | 202 | 2 | 1.606 | 77.7 | 2.21 | 2.66 | 166 | −5 |
| 131.6 | 173 | 2 | 1.670 | 79.2 | 2.22 | 2.20 | 135 | −6 |
| 129.5 | 147 | 2 | 1.679 | 78.9 | 2.24 | 3.04 | 182 | 0 |
| Average 94.5... | 140 | 40 | 1.582 | 78.6 | 2.13 | 2.49 | 157 | |

Tests B

| NON-PROTEIN NITROGEN PER 100 GRAMS BRAIN | NON-PROTEIN NITROGEN IN TOTAL NITROGEN | TOTAL NITROGEN IN BRAIN | WATER IN BRAIN | BRAIN WEIGHT | NUMBER RATS USED | AGE | BODY WEIGHT | NUMBER OF HOURS AFTER FEEDING |
|---|---|---|---|---|---|---|---|---|
| *mgms.* | | *per cent* | | *grams* | | *days* | *grams* | |
| 180 | 2.88 | 2.16 | 78.4 | 1.590 | 2 | 123 | 89.1 | 2 |
| 180 | 2.84 | 2.22 | 79.0 | 1.533 | 3 | 120 | 85.9 | 3 |
| 175 | 2.72 | 2.21 | 79.6 | 1.548 | 5 | 118 | 91.5 | 4 |
| 169 | 2.64 | 2.16 | 78.4 | 1.533 | 5 | 131 | 83.0 | 5 |
| 139 | 2.25 | 2.13 | 78.8 | 1.623 | 3 | 135 | 92.5 | 6 |
| 151 | 2.40 | 2.16 | 79.0 | 1.590 | 4 | 135 | 109.5 | 7 |
| 133 | 2.24 | 2.08 | 78.0 | 1.675 | 2 | 112 | 144.4 | 8 |
| 128 | 2.31 | 2.15 | 78.6 | 1.549 | 2 | 123 | 121.6 | 9 |
| 153 | 2.48 | 2.19 | 78.1 | 1.615 | 3 | 161 | 133.1 | 10 |
| 161 | 1.70 | 2.23 | 77.9 | 1.701 | 2 | 202 | 137.8 | 11.5 |
| 129 | 2.32 | 2.26 | 78.8 | 1.590 | 3 | 173 | 133.8 | 16 |
| 182 | 3.03 | 2.24 | 78.3 | 1.668 | 2 | 147 | 116.7 | 20 |
| Average 157.... | 2.57 | 2.18 | 78.6 | 1.601 | 35 | 140 | 111.2 | 8.5 |

Chart 16 shows the relations found. Two hours after feeding the amount of non-protein nitrogen in the brain is high. This amount diminishes almost steadily up to nine hours after feeding. It then increases up to twenty-four hours, returning to the value in the control. The relations for the percentage of non-protein nitrogen on total nitrogen are similar, and the differences in the percentage of water in the brain follow a like course.

The excitement of fighting and of electrical stimulation causes an increase in the content of non-protein nitrogen in the brain, Komine ('19 a).

*Spinal cord.* See References.

(*b*) *Peripheral* : *Degeneration, Regeneration.* Nittono ('23) reports that when the second and third branches of the trigeminus nerve are sectioned, retrogressive changes appear in the fibers after one day, and in the small cells of the ganglion between the first and second day. The degenerative processes are at their height from the 5th to the 20th day. Regenerating fibers are seen from the third to the fifth day on. Residual evidences of degeneration may be detected as late as 60 days after the operation. Similar responses, but less intense, occur on the *intact* side. For numerical data in the regenerating n. peroneus—see Greenman ('13.)

4. *Special senses.* The correlation between structure and function in the development of the special senses of the white (albino) rat has been studied by Lane ('17).

*Touch* : *Reactions.* Pricking with a needle, fetuses 16 mm. (crown-rump measurements) on flank, sides and snout produces slight but perceptible movements. At birth the rat responds to touch of a brush by contortion of the body—limb movements—and squeaks.

*Structural conditions.* In 16 mm. fetuses about a dozen anlagen of vibrissae are present in the snout. A reticulum formed by a few nerve fibers at the base of each vibrissa is seen. At birth there are more vibrissae, more fibers to each of them, more tactile fibers to skin.

*Equilibrium* : *Reactions.* In a fetus of 35 mm. the first indication of equilibrium sense appears. The rat maintains an upright position. At one day of age the rat makes awkward efforts to right itself when turned over on the back and sometimes succeeds. Later ages showed gradual improvement in equilibration with increasing powers of coördination.

*Structural conditions.* Fetus 35 mm. Semi-circular canals well formed and ampullae innervated. Cristae acusticae have sensory and supporting cells well differentiated. Central connections of the vestibular nerve well defined. The same conditions at birth. At later ages—muscle tonus—the use of the vibrissae and sight, all aid in equilibration.

*Smell*: *Reactions.* Age, one day. Apparent responses to olfactory stimuli were obtained at this age—reaction time long.

Later stages: olfactory sense gradually improves from day to day.

*Structural conditions.* At one day, olfactory area contains a few differentiated sensory cells.

Later stages: a gradual perfecting of the olfactory apparatus in general.

*Taste*: *Reactions.* First day after birth, sense of taste uncertain. All substances appear to be disagreeable.

Later stages: Sense of taste slowly developed.

*Structural conditions.* First day after birth—taste buds not demonstrated. Dome shaped papillae are present on the anterior part of the tongue.

Later stages: by the ninth day taste buds on the sides of the circumvallate papillae are found, and a decidedly different organ in the dome shaped papillae.

*Hearing*: *Reactions.* No reactions to sound before the 12th day after birth. From that age on there is a gradual but rapid increase in the ability to hear.

*Structural conditions.* By the 12th or 13th day the organ of Corti is differentiated in part and the cellular plug in the external auditory meatus, which was intact for the first eleven or twelve days, is undergoing liquefaction and has become imperfect. The next few days witness the complete differentiation of the organ of hearing.

*Sight*: *Reactions.* No response to light was obtained before the opening of the eyes on the sixteenth or seventeenth days.

*Structural conditions.* At 12 days the rods and cones are fairly well defined, but the accessory apparatus is less complete. At the time when the eyes open the plexus of blood vessels to the lens is still present, though much reduced.

*Integument—moulting.* The rat has a heavy winter and a light summer coat of hair. The winter coat is moulted in the early spring and the summer coat in the early autumn. The amount of hair at the two seasons, and according to age, has not been determined. During the moult the outline of the "hooded" pattern is sometimes revealed by the slower growth of the hair in the area of the pattern. This is more often seen in young animals.

*Semicircular canals.* When rats are rotated in a horizontal plane for ten seconds at the rate of 120 revolutions per minute, with the body fixed in a glass tube, the center of gravity of the rat centered on the rotator, and the head free, and then the rotation is suddenly stopped, ocular after-nystagmus appears. The number of seconds during which the after-nystagmus continues is given in table 94, where the data are entered according to the age of the animal (J. A. Detlefsen, MS.)

All the tests here recorded are initial, the rat having had no previous experience of this sort. Table 94 shows an evident decrease in after-nystagmus time with advancing age. In yet older rats the decrease is still more marked.

5. *Circulation.* See References.

6. *Blood and lymph.* Folin and Morris ('13) examined the blood from six full-grown rats which was collected over a little powdered potassium oxalate; the uric acid, total non-protein nitrogen and urea were determined by the methods of Folin and Denis ('13).

The figures obtained for 100 grams of blood were as follows: Uric acid, 2 mgm.; non-protein nitrogen, 38; urea, 22. This experiment was repeated twice, each time using for the analysis the mixed blood of six normal white rats, and 2.4 mgm. and 2.5 mgm. respectively of uric acid per 100 grams of blood were found. These are substantially the same figures as Folin and Denis ('13) found for normal human blood.

7. *Respiration.* Macleod ('07) has determined the $CO_2$ output at 30°C. for rats of about 170 grams in body weight, table 95.

Cramer ('08) has made corresponding observations on rats of from 40–60 grams in body weight, table 96.

TABLE 94

| AGE | SECONDS OF AFTER-NYSTAGMUS | | | | | | | | | | | | | | | | TOTAL | MEAN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | | |
| *days* | | | | | | | | | | | | | | | | | | |
| 30 | | | 1 | | 5 | 9 | 13 | 5 | 2 | | | | | | | | 35 | 12.60 |
| 40 | | | | 2 | 4 | 13 | 15 | 6 | 13 | 2 | 1 | | | | | | 56 | 13.27 |
| 50 | | 2 | 1 | 15 | 14 | 23 | 36 | 49 | 29 | 19 | 8 | 6 | 2 | 1 | | 2 | 207 | 13.67 |
| 60 | | | 3 | 18 | 11 | 20 | 11 | 8 | 6 | 4 | 1 | | | | | | 82 | 12.12 |
| 70 | | 1 | 8 | 15 | 11 | 10 | 1 | | | | | | | | | | 46 | 10.52 |
| 80 | | | 9 | 22 | 65 | 58 | 28 | 25 | 9 | | | | | | | | 216 | 11.86 |
| 90 | | 1 | 13 | 13 | 30 | 33 | 13 | 2 | 1 | | | | | | | | 106 | 11.26 |
| 100 | | 5 | 10 | 51 | 99 | 88 | 74 | 22 | 4 | | | | | | | | 353 | 11.66 |
| 110 | | | 4 | 12 | 21 | 16 | 5 | 1 | | 1 | 2 | | | | | | 62 | 11.42 |
| 120 | | 1 | 8 | 28 | 32 | 28 | 10 | 2 | | | | | | | | | 109 | 11.06 |
| 130 | | | 9 | 22 | 37 | 24 | 9 | 3 | 3 | | | | | | | | 107 | 11.22 |
| 140 | | 6 | 4 | 8 | 10 | 14 | 15 | 5 | 5 | | | | | | | | 67 | 11.67 |
| 150 | 6 | 9 | 29 | 35 | 39 | 39 | 34 | 5 | 1 | | | | | | | | 197 | 10.91 |
| 160 | | | | | | 2 | 3 | 2 | | | | | | | | | 7 | 13.00 |
| 170 | | 1 | 3 | 9 | 3 | | | | | | | | | | | | 16 | 9.88 |
| 180 | | | | 3 | 4 | 4 | 3 | | 1 | | | | | | | | 15 | 11.73 |
| Total.... | 6 | 26 | 102 | 253 | 385 | 381 | 270 | 135 | 74 | 26 | 12 | 6 | 2 | 1 | | 2 | 1681 | 11.81 |

$$\text{Mean} = 11.81 \pm 0.030$$
$$\sigma = 1.82 \pm 0.021$$
$$r_{xy} = 0.38 \pm 0.014$$
$$\eta_{zy} = 0.48 \pm 0.013$$
$$\eta^2_{xy} - r^2_{xy} = 0.094 \pm 0.0096$$

8. *Metabolism. Percentage of glycogen in the liver.* Normal young albino rats of about the same size (75 grams) were kept on a diet of bread and milk and the percentage of glycogen in the liver determined by the method of Pflüger, (Cramer and Lochhead, '13) table 97.

Further observations showed that the glycogen content was relatively high 3–5 hours after a meal, but after 15 hours fell so

TABLE 95

*Excretion of carbon dioxide in grams per kilo body weight and per minute at 30°C.*

| WEIGHT | NUMBER OF RATS | AVERAGE DURATION OF OBSERVATION | RECTAL TEMPERATURE OF RAT ON REMOVAL | LOSS IN WEIGHT OF RAT PER MINUTE AND KILO | AVERAGE $CO_2$ PER MINUTE AND KILOGRAM |
|---|---|---|---|---|---|
| A. In dry air | | | | | |
| *grams* | | *minutes* | *°F.* | | *grams* |
| 204 | 4 | 38 | 102.3 | 0.061 | 0.0325 |
| 177 | 3 | 80 | 100.7 | 0.048 | 0.0313 |
| 174 | 2 | 30 | 101.2 | 0.043 | 0.0315 |
| 139 | 2 | 30 | — | 0.081 | 0.0290 |
| Average of all observations | | | | | 0.0310 |
| B. In moist air | | | | | |
| 209 | 3 | 170 | 101.7 | 0.036 | 0.0306 |
| 173 | 5 | 160 | 101.8 | 0.033 | 0.0280 |
| 166 | 1 | 165 | — | 0.027 | 0.0290 |
| 133 | 4 | 209 | 101.7 | 0.038 | 0.0345 |
| Average of all observations | | | | | 0.0305 |

TABLE 96

*Fasting rats 18–24 hours after feeding. Duration of experiment one hour*

| NUMBER OF RATS | TOTAL WEIGHT | $H_2O$ DISCHARGED IN CG. CALCULATED PER RAT | $CO_2$ DISCHARGED IN CG. CALCULATED PER RAT | $O_2$ ABSORBED IN CG. CALCULATED PER RAT | $\frac{CO_2}{O_2}$ | $CO_2$ PER HOUR AND KILO IN GRAMS | $O_2$ PER HOUR AND KILO IN GRAMS | TEMPERATURE | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | In | Out |
| | | | | | | | | *°C.* | *°C.* |
| 2 | 95 | 10.5 | 17.0 | 16.0 | 0.76 | 3.52 | 3.37 | 14 | 16 |
| 3 | 130 | 9.7 | 15.7 | 15.3 | 0.74 | 3.61 | 3.54 | 17 | 20 |
| 3 | 170 | 9.3 | 15.0 | 14.7 | 0.74 | 2.65 | 2.59 | 17 | 20 |
| 3 | 170 | 9.0 | 16.7 | 17.7 | 0.68 | 2.94 | 3.12 | 18 | 21 |

TABLE 97

*Percentage of glycogen in liver. Data arranged according to increasing liver weight*

| WEIGHT OF LIVER | LIVER GLYCOGEN | WEIGHT OF LIVER | LIVER GLYCOGEN | WEIGHT OF LIVER | LIVER GLYCOGEN |
|---|---|---|---|---|---|
| *grams* | *per cent* | *grams* | *per cent* | *grams* | *per cent* |
| 3.8 | 0.3 | 4.7 | 1.4 | 5.1 | 1.0 |
| 3.8 | 0.4 | 4.7 | 2.6 | 5.1 | 1.4 |
| 4.5 | 1.0 | 4.7 | 3.0 | 5.3 | 1.1 |
| 4.6 | 2.7 | 4.8 | 3.4 | 5.5 | 1.0 |
| 4.7 | 1.0 | 4.9 | 2.2 | 8.9* | 2.2 |
| 4.7 | 1.1 | 4.9 | 2.2 | | |

* Pregnant.

low that it could not be accurately determined. A series of observations is given in table 98.

TABLE 98

*Disappearance of glycogen after feeding. Normal young albino rats. (Cramer and Lochhead, '13)*

| HOURS AFTER LAST MEAL | WEIGHT OF LIVER | LIVER GLYCOGEN | DIET |
|---|---|---|---|
| | *grams* | *per cent* | |
| 3 | 3.7 | 0.66 | Meat |
| | 5.8 | 1.68 | Bread and milk |
| | 4.4 | 3.58 | Bread and milk, fasting 24 hours previous to last meal |
| 7 | 4.5 | 0.51 | Bread and milk |
| | 4.5 | 2.43 | Bread and milk |
| | 4.8 | 2.24 | Bread and milk |
| | 4.5 | 1.52 | Bread and milk |
| 17 | 4.8 | <0.2 | Meat |
| 24 | 3.8 | <0.2 | Bread and milk |
| | 2.6 | <0.2 | Bread and milk |

A study of the nitrogen excretion has been made by Hatai ('05); Chicago colony: Ration—"Uneeda Biscuit" and water—table 99.

From observations on 89 male rats at different ages and weights as in table 99, the following results were obtained:

1. The total amount of urine increases with the weight up to 120 grams, then decreases very decidedly. From 180 grams it again increases up to 220 grams, beyond which weight it remains rather constant. A diminution of urine in animals between 120 and 180 grams, or approximately 70–125 days old, seems to be a normal phenomenon rather than mere statistical variation. Whether or not this is a phenomenon of adolescence needs further investigation. It must be noted, however, that puberty in the rat begins at about seventy days after birth. The smaller animals excrete a relatively greater quantity of urine than the larger animals.

2. The total amount of nitrogen is quite independent of the amount of urine, and increases constantly and continuously throughout life. The smaller rats, however, excrete a relatively greater quantity than the larger animals.

3. The percentage value of urinary nitrogen is 91 per cent of the total in the case of smaller animals, and 89 per cent in the case of the larger.

4. The total amount of nitrogen eliminated by the rat during twenty-four hours at different weights may be determined with a high degree of accuracy by the formula (40).

For the nitrogen exchange in normal albino rats, the average values for three 3 day periods are given according to increasing body weight in table 100 (Cramer and Pringle, '10).

TABLE 99

*Showing the average amount of urine, feces, and nitrogen per day. Male rats alone were used. Average values for body weight groups*

| BODY WEIGHT | NUMBER OF ANIMALS | URINE | FECES | NITROGEN IN URINE | NITROGEN IN FECES | TOTAL NITROGEN |
|---|---|---|---|---|---|---|
| *grams* | | *cc.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* |
| 38 | 8 | 5.7 | 216 | 46 | 3 | 49 |
| 53 | 7 | 10.4 | 135 | 68 | 5 | 73 |
| 70 | 8 | 12.8 | 223 | 96 | 8 | 104 |
| 85 | 5 | 12.6 | 329 | 94 | 13 | 107 |
| 99 | 6 | 11.8 | 264 | 120 | 9 | 129 |
| 106 | 6 | 16.8 | 305 | 117 | 11 | 128 |
| 116 | 5 | 18.3 | 318 | 134 | 11 | 145 |
| 127 | 4 | 16.7 | 460 | 121 | 16 | 137 |
| 144 | 5 | 16.3 | 256 | 144 | 9 | 153 |
| 156 | 5 | 14.5 | 503 | 149 | 16 | 165 |
| 162 | 4 | 13.2 | 394 | 148 | 20 | 168 |
| 178 | 4 | 12.5 | 412 | 168 | 18 | 186 |
| 191 | 3 | 14.9 | 229 | 181 | 12 | 193 |
| 207 | 4 | 16.4 | 496 | 174 | 20 | 194 |
| 220 | 2 | 21.0 | 475 | 182 | 26 | 208 |
| 239 | 4 | 18.2 | 566 | 187 | 20 | 207 |
| 266 | 4 | 22.1 | 639 | 229 | 27 | 256 |
| 298 | 5 | 18.5 | 731 | 260 | 29 | 289 |
| 333 | 3 | 20.9 | 919 | 279 | 27 | 306 |
| 370 | 3 | 15.0 | 637 | 277 | 29 | 306 |

These observations show that the nitrogen in the urine increases with the increase in body weight, while that in the feces and that retained, diminish.

The distribution of nitrogen in the urine has been studied by Ordway and Morris ('13) in young rats—two males and one female—and their results are given in table 101.

Folin and Morris ('13) have made similar studies in older rats and their determinations are given in tables 193 and 150.

It will be seen from examination of the average results that the percentage composition of rat urine differs but little from that of human urine.

TABLE 100

*Nitrogen exchange in normal albino rats. Diet of bread and milk—Cramer and Pringle ('10)*

| PERIOD | WEIGHT | WEIGHT OF NITROGEN | | | |
|---|---|---|---|---|---|
| | | Urine | Feces | Retention | In food |
| *days* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 3 | 187 | 0.728 | 0.113 | 0.239 | 1.08 |
| 3 | 192 | 0.766 | 0.102 | 0.212 | 1.08 |
| 3 | 217 | 0.881 | 0.077 | 0.122 | 1.08 |

TABLE 101

*The protein metabolism in normal young rats. Analyses of urine. Ordway and Morris ('13)*

| | MALE<br>Initial weight 42.7 grams<br>Final weight 41.0 grams<br>Duration 9 days | | MALE<br>Initial weight 46.5 grams<br>Final weight 51.5 grams<br>Duration 15 days | | FEMALE<br>Initial weight 42.5 grams<br>Final weight 39.0 grams<br>Duration 10 days | |
|---|---|---|---|---|---|---|
| | Average for 24 hours | Average | Average for 24 hours | Average | Average for 24 hours | Average |
| | *mgm.* | *per cent* | *mgm.* | *per cent* | *mgm.* | *per cent* |
| Total N | 45.6 | 100.0 | 29.1 | 100.0 | 21.0 | 100.0 |
| Urea N | 32.5 | 71.3 | 22.2 | 76.3 | 16.5 | 78.6 |
| Ammonia N | 4.1 | 9.0 | 2.02 | 7.0 | 1.89 | 9.0 |
| Uric acid N | 0.16 | 0.35 | 0.14 | 0.48 | 0.05 | 0.24 |
| Creatinine N. ($C_1$) | 0.49 | 1.08 | 0.40 | 1.37+ | 0.34 | 1.42 |
| Creatinine N. + Creatine N. ($C_1 + C_2$) | 0.53 | 1.16 | 0.42 | 1.44 | 0.44 | 2.1 |

TABLE 102

*Female rat weighing 290 grams. Average of 5 days*

| | MILLIGRAMS PER 24 HOURS | PER CENT |
|---|---|---|
| Total N | 173.50 | 100.00 |
| Urea N | 143.20 | 77.30 |
| Ammonia N | 9.10 | 5.20 |
| Uric Acid N | 0.69 | 0.40 |
| Creatinine N | 4.50 | 2.65 |
| Creatinine + Creatine N | 4.70 | 2.71 |

This conclusion is questioned by Hunter, Givens and Guion ('14) who worked with wild Norways having body weights of about 100 grams or less. Their data are given in table 104.

TABLE 103

*Male rat weighing 197 grams. Average of 6 days*

| | MILLIGRAMS PER 24 HOURS | PER CENT |
|---|---|---|
| Total N | 126.00 | 100.00 |
| Urea N | 105.90 | 84.00 |
| Ammonia N | 6.70 | 5.30 |
| Uric Acid N | 0.52 | 0.41 |
| Creatinine N | 2.90 | 2.30 |
| Creatinine + Creatine N | 3.00 | 2.38 |

They conclude that owing to the simultaneous high output of allantoin the urine of rats contains the same products of purine metabolism as that of other rodents, and contains them in the same proportions.

TABLE 104

*Protein metabolism in normal young rats*

| EXPERIMENT NUMBER | NUMBER OF ANIMALS | WEIGHT OF ANIMALS | DAYS OF EXPERIMENT | TOTAL NITROGEN | PURINE-ALLANTOIN N | | | | | PERCENTAGE OF SAME AS | | | URICOLYTIC INDEX | PURINE COEFFICIENT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Allantoin | Uric acid | Bases | Sum | Per cent of total N | Allantoin | Uric acid | Bases | | |
| | | *kgm.* | | *grams* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | | | | | | |
| 8 | 11 | 0.86 | 1–4 | 2.32 | 132 | 3.4 | 2.9 | 138.3 | 6.0 | 95.4 | 2.5 | 2.1 | 97 | 40 |
| 9 | 16 | 2.0 | 1–2 | 3.77 | 192 | 8.5 | 6.8 | 207.3 | 5.5 | 92.6 | 4.1 | 3.3 | 96 | 52 |
| 10 | 21 | 2.5 | 1–2 | 1.75 | 88 | 4.2 | 2.5 | 94.7 | 5.3 | 93.0 | 4.4 | 2.6 | 96 | 19 |
| Average | | | | | | | | | 5.6 | 93.7 | 3.7 | 2.7 | 96 | 37 |

The high output of uric acid is accordingly merely an expression of the fact that the whole purine metabolism, like the protein metabolism or energy exchange, of so small an animal is pitched at a far higher level than that of man.

Observations on the excretion of total nitrogen and uric acid in normal albinos fed during the experimental period on a thin soup of cracker crumbs and warm water (Morris and Rees, '23), are recorded in table 105.

The salt metabolism of the pregnant rat has been followed by Toverud ('23) and his results are given in table 106.

TABLE 105

*On total nitrogen and uric acid excretion in albino rats*

| | FIRST SERIES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rat A (170 grams) | | Rat B (158 grams) | | Rat C (172 grams) | | Rat D (255 grams) | | Rat X (310 grams) | | Rat Y (165 grams) | |
| | Total nitrogen | Uric acid | Total nitrogen | Uric acid | Total nitrogen | Uric acid | Total nitrogen | Uric acid | Total nitrogen | Uric acid | Total nitrogen | Uric acid |
| | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* |
| Foreperiod: | | | | | | | | | | | | |
| 1st day... | 78.8 | 1.20 | 84.0 | 0.98 | 63.8 | 0.63 | | | | | | |
| 2nd day.. | 78.0 | 1.00 | 102.0 | 1.12 | 82.5 | 0.78 | 124.5 | 1.24 | 129.0 | 2.22 | 139.5 | 2.18 |
| 3rd day... | 73.5 | 1.34 | 111.0 | 1.22 | 84.8 | 0.63 | 136.5 | 1.02 | 130.5 | 2.22 | 102.0 | 1.38 |
| Average day | 76.8 | 1.18 | 99.0 | 1.11 | 77.0 | 0.68 | 130.5 | 1.13 | 130.0 | 2.22 | 121.0 | 1.78 |

| | SECOND SERIES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Rat A (157 grams) | | Rat B (150 grams) | | Rat C (165 grams) | | Rat D (244 grams) | |
| | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *mgm.* |
| Foreperiod: | | | | | | | | |
| 1st day... | 115.5 | 0.96 | 92.3 | 1.09 | 73.5 | 0.65 | 132.0 | 0.88 |
| 2nd day.. | 99.8 | 1.00 | 108.0 | 0.55 | 103.5 | 0.71 | 111.0 | 1.09 |
| 3rd day.. | 114.0 | 0.95 | 112.5 | 0.98 | 123.0 | 0.83 | 147.0 | 1.18 |
| Average day | 109.8 | 0.97 | 104.3 | 0.87 | 100.0 | 0.73 | 130.0 | 1.05 |

TABLE 106

*General salt metabolism—rat—pregnant female—on normal diet. Experiment continued four days*

| INITIAL WEIGHT | GAIN IN WEIGHT | FOOD INTAKE PER 24 HOURS | CONSTITUENTS EXAMINED | AVERAGE INTAKE PER 24 HOURS | AVERAGE EXCRETION IN 24 HOURS IN | | BALANCE | ABSORPTION | RETENTION |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Urine | Feces | | | |
| *grams* | *grams* | *grams* | | *mgm.* | *mgm.* | *mgm.* | *mgm.* | *per cent* | *per cent* |
| 180 | 5 | 5.9 | Ca | 31.4 | 2.42 | 20.5 | + 8.48 | 35.5 | 27.0 |
| | | | Mg | 12.3 | 4.35 | 6.7 | + 1.25 | 55.5 | 10.2 |
| | | | P | 39.3 | 12.50 | 9.7 | +17.10 | 75.5 | 43.5 |

TABLE 107

*Food intake: Daily consumption of calories*

| EXPERIMENTS | NUMBER OF RATS EMPLOYED | PERIOD | AVERAGE DAILY CONSUMPTION IN CALORIES PER 100 GRAMS LIVE WEIGHT | |
|---|---|---|---|---|
| | | | Without milk | With milk |
| | | *days* | | |
| IV | 12 | 27 | 49.1 | 51.5 |
| V | 16 | 21 | 48.7 | 49.7 |
| VI | 18 | 24 | 48.4 | 50.7 |
| VII | 8 | 21 | 48.6 | 47.7 |

TABLE 108

*Food intake per week*

| BODY WEIGHT | (1) WITHOUT BUTTER-FAT | (2) WITH BUTTER-FAT |
|---|---|---|
| *grams* | *grams* | *grams* |
| 50 | 28.7 | — |
| 60 | 35.0 | 32.0 |
| 70 | 40.0 | 37.6 |
| 80 | 45.0 | 40.0 |
| 90 | 49.0 | 43.0 |
| 100 | 52.0 | 44.0 |
| 110 | 55.0 | 48.0 |
| 120 | 59.0 | 51.0 |
| 130 | 62.6 | 55.0 |
| 140 | 65.0 | 57.0 |
| 150 | 66.0 | 59.6 |
| 160 | 68.7 | 62.5 |
| 170 | 72.0 | 65.0 |
| 180 | 73.0 | 68.0 |
| 190 | 75.0 | 70.8 |
| 200 | 74.0 | 74.0 |
| 210 | 73.5 | 78.7 |
| 220 | 73.0 | 79.0 |
| 230 | | 78.0 |
| 240 | | 81.0 |
| 250 | | 80.0 |
| 260 | | 80.0 |
| 270 | | 82.0 |
| 280 | | 86.0 |
| 290 | | 87.0 |
| 300 | | 86.0 |

(*a*) *Bio-chemistry.* See References.

*Food intake.* For obvious reasons general statements concerning the food intake are unsatisfactory, but the following citations will serve to give some idea of the weight of food consumed under various conditions.

For growing rats, weighing about 40 grams at the beginning of the test, and about 80 grams at the end, and fed several different diets, each with and without milk, Hopkins ('12) reports the daily consumption of calories as given in table 107.

TABLE 109

*Group A (Controls) Kojima ('17 c). All the weights given are in grams*

| WEEK | WEEK ENDING | TOTAL WEIGHT OF GROUP | NUMBER OF RATS | AMOUNT OF FOOD CONSUMED | AMOUNT OF FOOD CONSUMED PER KILO OF BODY WEIGHT |
|---|---|---|---|---|---|
| | 1916 | | | | |
| I | February 4 | 1175 | 6 | 580 | 493.6 |
| II | February 11 | 1182 | 6 | 580 | 490.6 |
| III | February 18 | 1180 | 6 | 580 | 491.5 |
| IV | February 25 | 1043 | 5 | 520 | 498.5 |
| V | March 3 | 1055 | 5 | 525 | 497.6 |
| VI | March 10 | 1050 | 5 | 540 | 514.2 |
| VII | March 17 | 1040 | 5 | M. 476<br>R. 312 | M. 457.7<br>R. 300.0 |
| VIII | March 24 | 1050 | 5 | M. 489<br>R. 326 | M. 465.7<br>R. 310.4 |

M. = lean meat; R = rusks.

From weeks I–VI they were fed with "melox"; during weeks VII and VIII with lean meat (60 per cent) and rusks (40 per cent).

Osborne and Mendel ('15 a) report as shown in table 108 the rate of food intake in grams per week of male rats fed with edestin or casein plus protein-free milk, (1) without butter-fat (2) plus butter-fat. Each gram has a value of about five calories.

In table 109 are given the data from Kojima ('17 c) for rats weighing about 200 grams.

The data in table 108 show a consumption of about 7 grams per diem for a rat of 100 grams body weight and McCollum (MS.) reports the same. At 200 grams the intake is from 11 grams, table 108, to 14 grams, table 109. The relative weight of the food consumed decreases with the increase in body weight (table 108). Age also is probably a modifying factor, though this has not been studied. In feeding under the usual conditions allowance for wastage must be made.

Tabular records for the very important studies from the laboratories of Osborne and Mendel, McCollum and many others on the modifications of body growth by the use of various diets are reluctantly omitted because of the general plan of presenting in these pages data for the normal rat only.

The literature given under "Physiology: References" at the end of the chapter contains the citations by authors and dates grouped in accordance with the following scheme.

9. *Nutrition—general. Quantitative deficiency.*

(*a*) *Tests with:* Proteins, Fats, Carbohydrates, Salts, Vitamines.

(*b*) *Effects on systems and functions.* (a) Osseous system, ($a_1$) Reproductive system; (b) Reproductive function.

(*c*) *Body temperature.* Using the mercurial thermometer in the rectum, Pembrey ('95) reports a body temperature of 37.5°C. in adult Albinos. Macleod ('07) by the same method finds a range of 37.5–38.5°C. with a mean of 37.9°C.; Congdon ('12) also by the same method a temperature of 37.9°C. in the young; in the adult, when reared at 16°C., a temperature of 36.2°C. and when reared at 33°C., of 37.2°C.

The newborn rat is very responsive to changes in the external temperature. Temperature regulation is established at about 10 days of age—but is never perfect, even at maturity. The female has a somewhat higher temperature than the male, the excess for the female amounting to 0.74°C. in rats about 25 days old (Bierens de Haan, '22). There is a tendency for the body temperature to rise in the afternoon.

Graham and Hutchison ('14) using the thermoelectric method of Philips and Demuth, obtained the following ranges according to changes in the external temperature—table 110.

Bierens de Haan ('22) found the morning temperatures of young albino rats to be as in table 111.

These observations show an increase in body temperature with an increase in room temperature up to 30°C. at the rate of 0.7°C. for the body in response to 5°C. increase in the room temperature.

TABLE 110

| EXTERNAL TEMPERATURE | | BODY TEMPERATURE (C) | |
|---|---|---|---|
| | | High | Low |
| 5°C. | Series (a) | 36.1 | 21.1 |
| | Series (b) | 34.9 | 19.0 |
| 21°C. | | 38.7 | 32.4 |
| 37°C. | | 41.8 | 32.9 |

On change of surrounding temperature the adjustment of the caloric output lags. Thus rats brought from a cold to a warm room have a *higher* body temperature than rats habituated to the warm room, Przibram (Personal, 1923).

The rat therefore regulates but poorly its body temperature and is somewhat poikilothermous.

TABLE 111

*Body temperature according to room temperature*

| TEMPERATURE OF ROOM (CONSTANT) | AGE ON FIRST DAY OF EXPERIMENT | NUMBER OF INDIVIDUALS (ONE BROOD EACH) | BODY TEMPERATURE MEASURED DURING | | DIFFERENCE IN BODY TEMPERATURE FOR 5° ROOM TEMPERATURE |
|---|---|---|---|---|---|
| | *days* | | | *days* | |
| 10°C. | 24 | 8 | 34.8°C. | (4) | 0.7°C. |
| 15° | 24 | 8 | 35.5° | (4) | 0.7° |
| 20° | 25 | 6 | 36.2° | (4) | 0.7° |
| 25° | 24 | 6 | 36.8° | (4) | 0.7° |
| 30° | 23 | 7 | 37.5° | (4) | 0.3° |
| 35° | 23 | 5 | 37.8° | (2) | |

(*d*) *Calorimetry.* According to the experiments of Hill and Hill ('13) a fasting rat of 100 grams gives out approximately 20 calories per day. The ratio H/W (H = total heat; W = body weight) is fairly constant above 90 grams in body weight, i.e. the fasting heat production is directly proportional to the body weight.

In relation to the body surface H/W ($W^{\frac{2}{3}}$ = relative body surface) the heat production is high in group 1—young active animals with a relatively large body surface; lowest in group 2—90–130 grams in body weight; and somewhat higher in group 3—see table 112 which gives:

(I) The weight of the rat after 24 hours fast.
(II) The temperature of the calorimeter during the experiment.
(III) The time of year.
(IV) The heat production for relative areas calculated per body weight (grams) $^{\frac{2}{3}}$ i.e. $H/W^{\frac{2}{3}}$.
(V) The heat production calculated per body weight (grams) H/W.

In animals living together the heat production per gram is less than in the same animals living separately, and it has been observed that when living together the rats grow faster (Hopkins, '13) than when living alone.

For the direct determinations of the area of the skin (Hill and Hill, '13) see page 121.

10. *Reproduction and the sex organs.* The relations between fertility and nutrition are very evident in the rat and the existence of a dietary factor essential for reproduction has been postulated, Evans and Bishop ('22 d).

Przibram has found that rats put in the cold room early in the autumn and then removed to a warm room breed from then throughout the winter, thus avoiding the interruption to breeding from November to January, which occurs under the usual conditions. Constancy of (moderate) temperature is in general favorable to continuous reproduction.

In the immature female the vagina is closed by a membrane. This usually breaks down just before the first oestrus. Table 113 gives the data on these relations and also the length of the first four oestrous cycles (Long and Evans '22).

The later oestrous cycles are about five days in length (4.6–4.8). In each cycle four stages are recognized (Long and Evans, '22)

TABLE 112

*Heat production per 24 hours in rats fasting 24 hours before the beginning of the experiment*

Weight in grams: Heat production in gram-calories—24 hours

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Group 1: | | | | | | | | | | | |
| Weight of animal | 50.5 | 62 | 70 | 71 | 76 | 78 | 82 | 87.5 | | | |
| Temperature | 14° | 14° | 14° | 14° | 15.5° | 13° | 15° | 14° | | | |
| Time of year | Aug. | Aug. | Dec. | Dec. | Aug. | Dec. | Aug. | Oct. | | | |
| $H/W^{\frac{2}{3}}$ | 1234 | 1540 | 1279 | 1297 | 1500 | 1437 | 1497 | 1530 | | | |
| H/W | 325 | 390 | 311 | 314 | 355 | 337 | 345 | 345 | | | |
| Group 2: | | | | | | | | | | | |
| Weight of animal | 96 | 103 | 103 | 117 | 118 | 118 | 122.5 | 124 | 127 | 129 | 129 |
| Temperature | 14.5° | 14° | 14° | 14° | 13.2° | 14° | 12.8° | 13° | 14.5° | 14° | 15° |
| Time of year | Oct. | Nov. | Aug. | Nov. | Sept. | Nov. | Sept. | Nov. | Oct. | Nov. | Aug. |
| $H/W^{\frac{2}{3}}$ | 1048 | 843 | 967 | 834 | 980 | 940 | 1194 | 960 | 1170 | 917 | 1035 |
| H/W | 229 | 180 | 206 | 171 | 200 | 192 | 241 | 193 | 233 | 182 | 205.5 |
| Group 3: | | | | | | | | | | | |
| Weight of animal | 133 | 133 | 136 | 143 | 148 | 152 | 153.5 | 158 | 175 | 191 | 235 |
| Temperature | 14.5° | 12.4° | 15° | 15° | 12.8° | 11° | 14.5° | 12° | 13.5° | 15° | 12° |
| Time of year | Oct. | Sept. | Oct. | Oct. | Sept. | Oct. | Oct. | Nov. | Nov. | Oct. | Sept. |
| H/W | 1126 | 1115 | 1158 | 1000 | 1055 | 1122 | 945 | 1100 | 1162 | 1160 | 1152 |
| H/W | 221 | 219 | 206 | 192 | 200 | 211 | 177 | 204 | 208 | 202 | 187 |

and in the previous tables 2, 2a, 3, and 4 these have been given, together with a description of the vaginal smear which characterizes each stage.

The sexual behavior of the young male has been studied in great detail by Stone ('22).

Long and Evans ('22, pp. 70–74) also describe the behavior during mating. There is left in the vagina, after copulation, a so-called vaginal plug, formed by the male. This may remain in place from 12–24 hours and is a trustworthy sign of insemination.

At about the 14th day of pregnancy a deposit of blood may be seen in the upper part of the floor of the vagina. This occurs only at this phase and persists some three days. It is known as the "placental sign" and is the earliest infallible sign of pregnancy which may be detected in the living animal.

TABLE 113

*Age in days at opening of vagina and at first ovulation, and length in days of first four oestrous cycles in a group of 200 rats.*

| | RANGE | AVERAGE |
|---|---|---|
| Age at opening | 34th–109th day | 72nd day of life |
| Age at first ovulation | 45th–147th day | 77th day of life |
| Length of first cycle | 3–37 days | 10 days |
| Length of second cycle | 3–25 days | 9 days |
| Length of third cycle | 4–26 days | 8.5 days |
| Length of fourth cycle | 3–23 days | 7.3 days |

In the series studied by Long and Evans ('22) there were found for one ovulation 5.2 corpora lutea in one ovary or 10.4 in both. The average number of eggs was 9.6 in both oviducts and the average number of young born 7. Thus there has been a loss at each step between ovulation and parturition.

*Weight of ovaries during gestation and lactation.* The changes in the weight of the ovaries during gestation and lactation have been followed by Stotsenburg ('23). The change in weight during gestation for rats weighing 200 grams is illustrated by chart 17.

The changes in the weight of the ovaries during lactation are shown in chart 18.

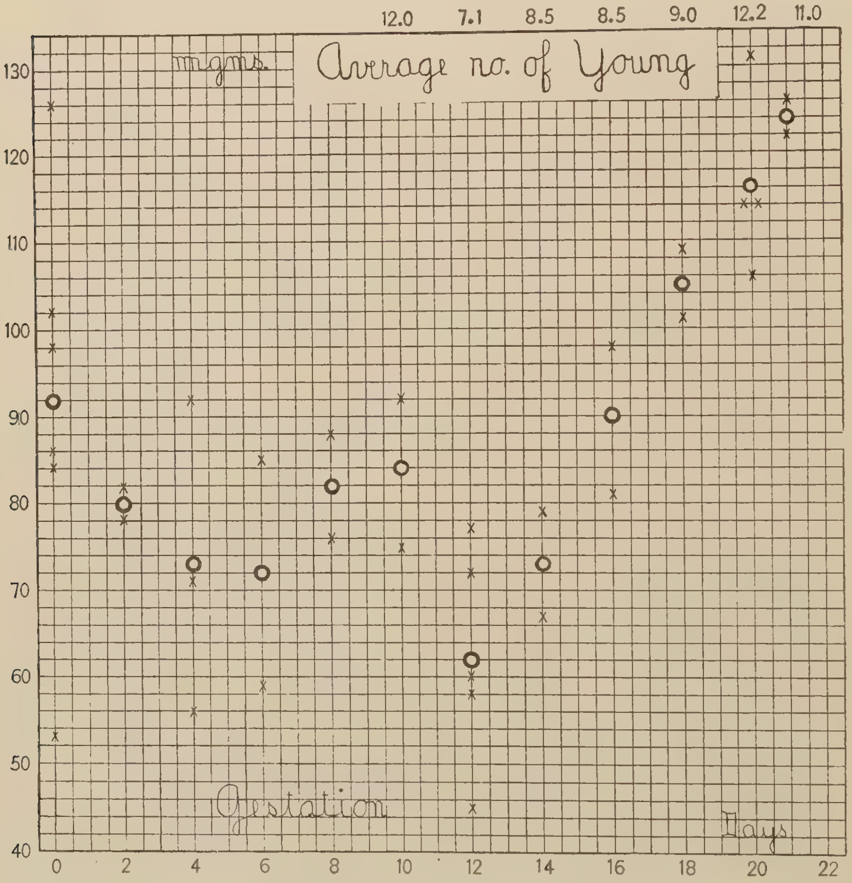

Chart 17 Giving in milligrams the weight of both ovaries at twelve periods during gestation. The mean value for each period is indicated by a heavy circle—the individual values by a cross. Days entered below and the average number of fetuses above. The mean ovulating weight of the ovaries is 49 mgm.

The values which appear in these charts depend mainly on the number and size of the corpora lutea. For a discussion of these structures see Long and Evans ('22).

When the young are removed from the mother at birth the ovaries fail to show the loss in weight which occurs during the later days in normal lactation.

In another series of 52 cases, Evans and Bishop ('23) determined that 69 per cent of the discharged ova were implanted and that of these latter about 9 per cent were resorbed. Out of three series, 4.2 per cent were born dead.

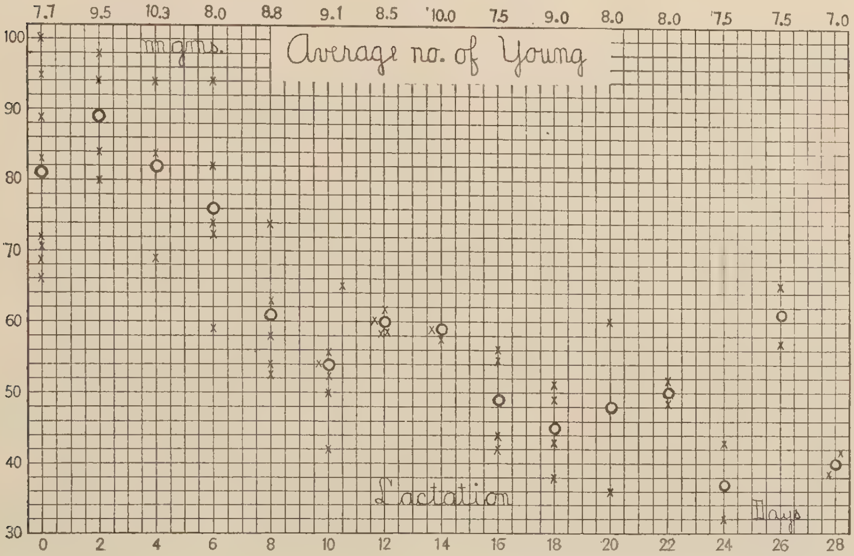

Chart 18 Giving in milligrams the weight of both ovaries at fifteen intervals during lactation. The mean value for the period is indicated by a heavy circle. The individual values by a cross. Days entered below and the average number of young above. The mean ovulating weight of the ovaries is 49 mgm.

In the Institute colony about 2 per cent of the young are dead at birth—a proportion similar to that found in man—but the ratio of the dead born males is 129 to 100 females, King ('21).

The number of litters born is only slightly less (97.5 per cent) than that to be expected from the "placental sign." Of the litters born, about 86 per cent were successfully suckled, and at weaning the mothers were 6.4 per cent heavier than at littering, Evans and Bishop ('23).

*Sex organs:* (*a*) *Male.* See References.

(*b*) *Female.* The placenta is not permeable for adrenalin (Shimidzu '20) but is permeable for all basic dyes tested by Shimidzu ('22) while among fifteen acid dyes eight penetrated the placenta. Permeability is determined by the colloidal state of the dye in the serum.

During the several stages of oestrus and during all the phases of the reproductive cycle, the female reproductive organs all show concomitant modifications.

The contractions of the longitudinal muscles of the uterus, in relation to the phases of the oestrus cycle, have been studied by Blair ('23) using the method of Kehrer ('07). The mean contraction rate for the maximal contractions was slower during oestrus than during the dioestrus. The rate for the submaximal contractions varied widely, but the mean rate was little affected by the phases of the cycle. The average values for six groups of tests are given in table 114.

TABLE 114

*Mean contraction rates of uterus*

D = dioestrous interval. O = oestrous

| SIX GROUPS | RATE PER HOUR | | | | | |
|---|---|---|---|---|---|---|
| | Maximal contractions | | Submaximal contractions | | All contractions | |
| | D. | O. | D. | O. | D. | O. |
| Adults : both methods..... | 41.4 | 25.6 | 31.6 | 33.6 | 73.0 | 59.2 |
| Number of experiments.... | 24 | 36 | 24 | 36 | 24 | 36 |

11. *Exocrine system. General.*

(*a*) *Mammary function.* See References.

(*b*) *Feeding exocrine glands.* See References.

12. *Endocrine glands.*

(*a*) *General.* See References.

(*b*) *Testes.* See References.

(*c*) *Ovaries.* See References.

(*d*) *Suprarenals.* The possible change in the weight of the suprarenals during pregnancy and lactation has been examined by J. C. Donaldson ('24). The results are given in table 115.

From this study the author concludes as follows:

1. No increase in weight of the adrenal glands during pregnancy and lactation occurs in normal albino rats free from visible signs of disease.
2. An increase in weight of the adrenal glands occurs in unmated rats suffering from gross pathological lesions represented by lung infections and infections of the middle ear.
3. A further increase in weight of the adrenals occurs during pregnancy in rats suffering from pathological conditions.

The adrenals increase in weight several fold in animals starved from 10–12 days, Vincent and Hollenberg, '20.

TABLE 115

*Percentage deviations in the weight of the adrenals of pregnant and lactating albino rats. Based on body weight. Values in table 148 used as a standard*

| GROUPS | NUMBER OF CASES | MEAN BODY WEIGHT | MEAN BODY LENGTH | MEAN WEIGHT OF BOTH ADRENALS | MEAN PERCENTAGE DEVIATION | PROBABLE ERROR OF THE MEAN |
|---|---|---|---|---|---|---|
| | | *grams* | *mm.* | *mgm.* | | |
| Healthy controls | 29 | 166 | 187 | 44.7 | +2.67 | ±1.87 |
| Pregnant and lactating | 29 | 168 | 188 | 45.3 | +1.86 | ±2.34 |
| Pathological controls | 48 | 179 | 191 | 47.9 | + 6.4 | ±1.89 |
| Pregnant and lactating | 51 | 221 | 203 | 57.8 | +11.8 | ±1.98 |

(*e*) *Thyroid and parathyroids.* The amount of intestine contracting substances in the thyroid of the rat according to age has been studied by Hammett and Tokuda ('21). The duodenal segments, prepared with precautions determined by Hatai and Hammett ('20), were standardized in a solution containing 0.25 cc. of M/10 $Na_2$ $Co_3$ and the shortening induced by a like concentration of thyroid extract was expressed as a percentage of the standard value. The results are presented in table 116 and chart 19.

In general the extract produces an increasing amount of contraction up to about 150 days of age—after which the effect diminishes rapidly. The response is more marked for the male than for the female. There are however significant high values at birth, weaning, puberty and during rapid growth—the female leading. It is concluded that these changes in the thyroid extract are particular expressions of general changes in the organism in which the thyroid participates.

The influence of the parathyroid and thyroid tissue on the creatinine-creatine balance in incubated extracts of muscle tissues has been followed by Hammett ('21). His results indicate that the addition of parathyroid tissue to extracts of muscle tissue, in acid, neutral or alkaline mixtures, directly *retards* the increase of creatinine formation normally occurring under these conditions. The addition of thyroid tissue to similar extracts is without effect.

TABLE 116

*The age and sex distribution of the animals the thyroid extracts of which were tested, together with the averages of the intestine-contracting power of the extracts according to the individual age groups*

| MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|
| (1) Age | (2) Number of tests | (3) Number of rats | (4) Contraction in terms of M/10 Na$_2$CO$_3$ | (5) Age | (6) Number of tests | (7) Number of rats | (8) Contraction in terms of M/10 Na$_2$CO$_3$ |
| *days* | | | *per cent* | *days* | | | *per cent* |
| New-born | 3 | 15 | 73.8 | New-born | 4 | 31 | 86.5 |
| 10–11 | 3 | 9 | 41.0 | 10–11 | 2 | 10 | 64.0 |
| 15 | 3 | 6 | 47.2 | 14–15 | 2 | 6 | 92.9 |
| 20 | 3 | 6 | 56.8 | 21–22 | 2 | 4 | 72.2 |
| 25 | 3 | 6 | 43.4 | 25 | 2 | 3 | 111.6 |
| 30 | 3 | 6 | 83.9 | 30 | 2 | 3 | 45.0 |
| 40 | 3 | 3 | 41.3 | 39 | 2 | 2 | 52.9 |
| 50 | 3 | 3 | 63.0 | 50–52 | 3 | 3 | 83.3 |
| 60 | 3 | 3 | 70.5 | 54–55 | 3 | 3 | 63.9 |
| 70 | 4 | 4 | 75.9 | 60 | 2 | 2 | 86.1 |
| 79–80 | 3 | 3 | 167.5 | 70 | 2 | 2 | 72.1 |
| 90 | 2 | 2 | 119.8 | 75 | 2 | 2 | 72.1 |
| 100 | 1 | 1 | 121.4 | 81–83 | 3 | 3 | 105.0 |
| 125 | 3 | 3 | 138.6 | 90 | 3 | 3 | 99.5 |
| 150 | 3 | 3 | 228.8 | 100 | 3 | 3 | 101.7 |
| 200 | 3 | 3 | 101.7 | 125 | 1 | 1 | 95.0 |
| 460 | 1 | 1 | 38.1 | 150 | 4 | 4 | 164.6 |
| 500 | 2 | 2 | 59.2 | 300 | 4 | 4 | 38.6 |
| 520 | 1 | 1 | 68.4 | | | | |

*Removal of the thyroid plus the parathyroids, and of the parathyroids alone.* Hammett 1921–1924 has made a series of observations on the effects of thyroparathyroidectomy and of parathyroidectomy. A condensed summary of the more important results is here presented. The groups from which the entire thyroid apparatus had been removed are briefly designated as "Thypars" and those from which the parathyroids alone had been removed as "Parathys."

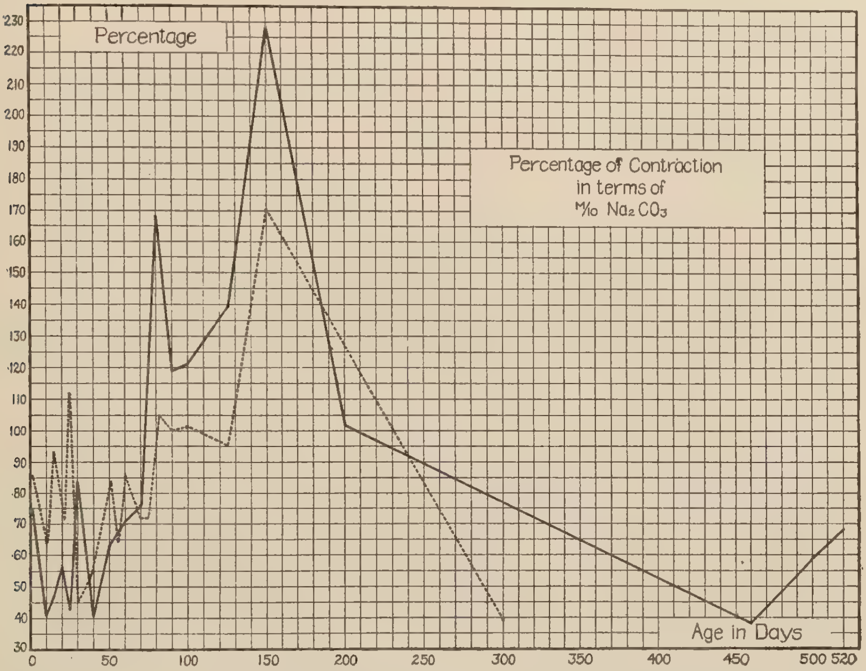

Chart 19 Showing the changes in the intestine-contracting power of equivalent amounts of thyroid extracts from male and female albino rats according to age.

In the series of studies now complete, the operation was made at 100 days of age and the animals were killed at 150 days. In a less complete series, still in progress, the operation was made at 75 days and the killing as before, at 150 days. Unless otherwise stated, the conclusions are based on rats operated at 100 days of age. Condensed data table 117.

As previously noted (p. 134) these operations, both of which involve removal of the parathyroids, were accompanied by the smallest post-operative mortality when carefully tamed and gentle rats were used. The effects observed were all measured in relation to litter mate controls of the respective test animals.

*Effect on body length, body weight and tail length (Hammett, '23 and '24),* "Thypars." The growth of the body in weight was the most retarded. The retardation was more marked in the females. A lesser retardation of gross growth occurred when the thyroid apparatus was removed at 75 days.

"Parathys." The same effects were observed, but to a lesser degree, in the rats operated at 100 days. In those from which the parathyroids were removed at 75 days the gross growth of the males was more retarded than was that of the females. Table 117.

*Effects on growth and composition of the long bones (Hammett, '23, '24).* In the "Thypars" there is retardation of growth of humerus and femur in length and weight. Ossification is retarded and dessication is produced. The humerus is more affected than the femur. The calcium of the ash is not affected in the males but is decreased in the females. In both sexes the magnesium and phosphorus tend to be increased.

In the "Parathys" there is retardation of growth in length and weight of the long bones, but to a lesser degree than in the "Thypars." No disturbance in the percentage of ash, water or organic matter is caused in the males. In the females ossification is retarded. In the males there is no change in calcium content of the ash, but the magnesium and phosphorus increase. In the females the latter occurs, together with a decrease in calcium.

*Effect on the incisor teeth (Hammett, '22).* "Thypars." Defects of the incisor teeth do not usually occur.

"Parathys." (Operation at 75 days). Fragility, leading to the breaking off of the tooth; a change from the normal semi-translucency to a pathological snowy white opacity, together with a tendency to loss of pigment and to overgrowth due to displacement, all occur frequently.

These effects, not found in the "Thypars," from which the parathyroids were also removed, are interpreted as "expression of a summation of stimulation of metabolism."

*Effect on the growth of the brain and spinal cord* (*Hammett, '23*). In "Thypars" there is a marked retardation of the growth of the brain and cord. The inhibition of the growth of the brain is much greater than that of the cord. The results are more marked in the female than in the male. Table 117.

In "Parathys" there appears a slight but significant retardation of the growth of the cord and of the female brain. The growth of the male brain is not retarded. In general the inhibition is very much less than that caused by the loss of the thyroid secretion, but the effect on the females is greater than that on the males.

TABLE 117

*The relative per cent increments of the body and the several organs from 100 to 150 days of age using the controls = 100 per cent, as base*

| MALES | | | FEMALES | | |
|---|---|---|---|---|---|
| Part | Thypars | Parathys | Part | Thypars | Parathys |
| B. L. | 35.2 | 64.0 | B. L. | 24.5 | 47.2 |
| B. W. | 31.0 | 57.1 | B. W. | −28.2 | 20.7 |
| T. L. | 37.2 | 63.9 | T. L. | 19.4 | 49.3 |
| Brain | 20.5 | 108.3 | Brain | 3.4 | 89.8 |
| Cord | 51.9 | 90.8 | Cord | 53.7 | 87.6 |
| Testis | 51.2 | 109.2 | Ovary | −236.3 | −90.3 |
| Epidid | 65.0 | 97.2 | Uterus | −107.7 | −31.1 |
| Hypop | 162.2 | 58.4 | Hypop | 66.7 | 60.2 |
| Adrenals | −123.0 | 18.1 | Adrenals | −124.7 | −3.9 |
| Pancreas | −42.0 | 86.5 | Pancreas | −124.5 | 72.8 |
| Thymus | −157.2 | −46.3 | Thymus | −556.2 | −321.2 |
| Thyroid | | 63.9 | Thyroid | | 47.3 |
| Heart | −26.7 | 76.9 | Heart | −48.4 | 78.2 |
| Lungs | −21.9 | 25.7 | Lungs | −47.8 | 80.6 |
| Liver | −43.5 | 63.0 | Liver | 18.0 | 57.3 |
| Kidneys | −39.1 | 33.8 | Kidneys | −82.8 | 23.5 |
| Spleen | −38.1 | 139.1 | Spleen | −121.1 | 128.1 |
| Submax | 0.6 | 130.5 | Submax | 0.5 | 209.4 |
| Eyeballs | 83.5 | 100.6 | Eyeballs | 50.4 | 75.5 |

*Effect on the reproductive system* (*Hammett, '23*). "Thypars." In males the growth of the testes and epididymis is slightly retarded.

In females the ovaries and uterus not only stop growing, but actually retrogress and lose weight. The ovaries are the more affected.

"Parathys." The males are not affected. The effects in the females are similar to those in the "Thypars" but in less degree. Table 117.

*Effect on the glands of internal secretion (Hammett, '23).* "Thypars." In the male the growth of the hypophysis is accelerated. Absolute cessation of growth and a high degree of retrogression is shown by the adrenals, pancreas and thymus. The thymus is most affected.

In the female the growth of the hypophysis is retarded, but the other glands are affected as in the male.

"Parathys." In the male there is retardation of growth in the hypophysis, adrenals, pancreas and thyroid. The thymus shows a considerable degree of retrogression. In the female the effects are similar, but more marked than those in the male, except in the case of the hypophysis—table 117.

*Effect on the viscera (Hammett, '22 and '23).* "Thypars." In the male there is absolute inhibition and also retrogression in the growth of the heart, lungs, liver, kidneys and spleen. Growth in the submaxillaries is stopped.

In the female the effects are as in the male, except in the case of the liver. The retrogressive changes are more marked in the female.

"Parathys." In both sexes there is inhibition only, except in the spleen and submaxillary, which grow excessively.

*Effect on the refractive index and water content of the blood serum (Hammett, '23).* "Thypars." Male rats show a decrease in the water content of the serum and an increase in the refractive index of such a nature as to allow the conclusion that a true partial desiccation of the serum has occurred without a great alteration in the nature or distribution of the refractive solutes.

In female rats the operation produces a state of partial inanition, the effect of which on the serum is to counterbalance the desiccatory effect of the thyroid loss when growth in body weight occurs after such a loss.

"Parathys." The effects are the same for both sexes. There is no alteration in the concentration of total solids of the blood serum which appears when the rats are 150 days old. There is a change in the nature or the distribution of the refractive substances aside from the solvent water. This change is in the same direction and of approximately the same degree in the two sexes.

*Effect on reproduction* (*Hammett, '22*). Studies have been made of the reproductive ability of thyroidless albino rats. It was found that conception occurred when male "thypars" or "parathys" were mated with female "thypars" or "parathys."

When the thyroid apparatus was removed from young rats 45 or 56 days of age, there was no apparent inhibition of function of the internal secretion of the gonads (stimulation to development of the secondary sexual characteristics; stimulation to sexual activity; preparation of the uterine mucosa for nidation).

The formation, maturation and discharge of the gametes were however disturbed by the loss or deficiency of the thyroid secretion, as were the reproductive processes subsequent to gonadal participation. This is shown by the increased sterility, greater age at breeding, high birth mortality, high mortality during and after weaning, the smaller number of rats in the litters, and the failure of the rats to thrive during the nursing period, as do the young of normal mothers.

13. *Pineal gland.* See References.

14. *Hypophysis.* The influence of diet on the extracts of the hypophysis and the thyroid, tested against the intestinal strip, was studied by Degener ('22). The diets used were oatmeal, vegetables (fresh), meat and the standard diet plus potassium iodide. The extract of the entire control hypophysis causes a relaxation of the strip; with the oatmeal and vegetable diets it causes a contraction. In the controls the extract of the glandular portion alone causes contraction, that of the nervous portion alone, relaxation. The experimental diets which are effective produce an extract of the entire gland similar in reaction to that of the glandular portion alone.

The extract of the thyroid gland was not modified in its action by diet.

*Excitement and starvation.* The effect of general excitement or fighting on the secretion of the several ductless glands, as indicated by the reaction of an intestinal strip to the extracts, has been tested by Uno ('22). The extracts of the test thyroid and the test suprarenals were not modified. The extract of the test hypophysis however caused a contraction of the strip, the response characteristic for the glandular portion of the hypophysis, while that from the control glands caused a relaxation.

After starvation for 10–12 days the thyroid is greatly increased in weight behaving under these conditions like the adrenal; Vincent and Hollenberg, '20.

15. *Feeding endocrine glands.*

(*a*) *General.* See References.

(*b*) *Hypophysis.* See References.

(*c*) *Thyroid.* As the result of feeding small quantities of fresh sheep thyroid to rats, Cramer and Krause ('13) found a unique condition of the carbohydrate metabolism.

Owing to the inhibition of the glycogenic function, the liver contains only traces of glycogen. There is no glycosuria and the tolerance for glucose is only slightly diminished. The action of the thyroid on protein metabolism is effected partly through its action on carbohydrate metabolism, for the distribution of the nitrogen constituents of the urine is very similar to that observed after withdrawal of carbohydrates from the diet.

As the results of feeding thyroid preparations to young rats, Cameron ('23) reports that the principal organs, heart, liver, kidneys, adrenals, spleen, lymph glands and pancreas, hypertrophy; fat disappears. The animals' thyroid ceases to grow. Muscle does not develop at the usual rate. The growth rate diminishes. Cessation of the feeding of the thyroid is followed by a return to the normal.

(*d*) *Suprarenals.* See References.

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*Equivalent ages.* Donaldson, '06, '08, '10, '18. Hatai, '17.

*Technique.* Hammett, '21 i, '22. Osborne and Mendel, '12 d. Woithe, '07.

*Musclès and nerves.* Dubois, 1898. Engelmann, 1877. Hammett, '21 a, '21 b, '22. Hatai and Hammett, '20. Lee, '10.

*Exercise.* Donaldson, '11. Hatai, '15. Keith and Mitchell, '23. Kocher, '16.

*Nervous system. Central:* Hammett, '23 c. Hatai, '07 a, '08, '15 a, '17. *Brain:* Bianchi, '22. Ferrier, 1886. Hatai, '04 a. Komine, '19, '19 a. Mills, 1897. Ranson, '03. Schäfer, 1900. Watson, '05 c.

*Degeneration.* Nicholson, '23. Nittono, '23. Ranson, '04, '06, '09, '14, '14 b.

*Regeneration.* Greenman, '13, '16. Morpurgo, '23. Tournade, '13.

*Special senses.* Bogardus and Henke, '11. Hunter, '14. Kreidl and Yanase, '07. Lane, '17. Vincent, '12, '13, '15, '15 a, '15 b.

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*Respiration.* Barcroft and Barcroft, '23. Bert, 1878. Boycott and Damant, '08. Boycott, Damant and Haldane, '08. Cramer, '08. Hill and Macleod, '03. MacArthur and Jones, '17. Macleod, '07. Pembrey, 1895. Pembrey and Spriggs, '04. Prince, '17.

*Metabolism.* Abelin, '22. Ackroyd, '14. Astaschewsky, 1877. Basch, 1870. Basler, '09. Bohlen, 1894. Carlier, '05. Cooper, '23. Copeman and Hake, '08. Cramer, '08. Cramer and Lochhead, '13. Cramer and Pringle, '10. Cunningham, '20. Drasch, 1886. Eimer, 1869. Ellenberger, '06. Elliott and Barclay-Smith, '04. Falk, Noyes and Sugiura, '22. Faure, and Soula, '13. Folin and Morris, '13. Gage, '23. Goldmann, '09. Gruetzner, 1875, 1878, 1894, 1898, '05. Gulick, '22. Hatai, '05, '17 a. Hohmeier, '01. Hunter, Givens and Guion, '14. Jolyet and Chaker, 1875. Langley, 1879. Langley and Sewall, 1879. McMaster, '22. Macleod, '07. Mattges and Marquardsen, 1898. Mills, Dorst, Mynchenberg and Nakayama, '23. Mitchell, Shonle, and Grindley, '16. Morris and Rees, '23. Oliver, '21. Ordway and Morris, '13. Osborne and Mendel, '14 e. Paneth, 1888, 1888 a. Ranvier, 1887, 1888, 1894. Schiff, 1859. Toverud, '23. Vignes, '13. Zawarykin, 1883.

*Biochemistry.* Burnett, '18. Clifford, '21, '22. Cramer and Pringle, '10 a. Cramer and Lochhead, '13. Emmett and Luros, '19 a. Fisher, '23 a. Funk, Harrow and Paton, '23. Hammett, '21 f, '22, '22 a, '23 a, '24 b. Hammett and Nowrey, '22 a. Hanson, '21. Hatai and Hammett, '20. Hopkins and Dixon, '22. Hunter, Givens, and Guion, '14. Koch and Voegtlin, '16. Kreidl and Neumann, '08. Levine, McCollum and Simmonds, '22. Lewis and Root, '20. McCollum, '09. MacDonald, '22. Mellanby, '08. Mitchell, Nevens and Kendall, '22. Moulton, '23. Myers and Fine, '15. Nicolaier, '02. Noyes, Sugiura and Falk, '23. Osborne, Wakeman and Ferry, '19. Rohdé and Jones, '09. Shanks, '23. Shimidzu, '22. Sugiura, Noyes and Falk, '23. Zilva, '20, '20 a. Zucker and Gutman, '22.

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*General nutrition.* Abderhalden, ’19. Aron, ’12, ’13. Bond, ’22. Brüning, ’14 a. Czermak, 1895. Damon, ’23. Daniels and Nichols, ’17. Daniels and Loughlin, ’18. Falta and Noeggerath, ’05. Ferry, ’20. Givens and Cohen, ’18. Hale, ’23. Hawk, Fishback and Bergeim, ’19. Hoffman, ’23. Hogan, ’16, ’17 a, ’18. Jacob, ’06. Johns, Finks and Paul, ’20. Johns and Finks, ’20 a. Lane-Claypon, ’09. McCollum and Davis, ’15 a, ’15 c, ’15 d, ’15 e, ’15 f. McCollum, Simmonds and Pitz, ’16 a, ’16 c, ’16 f, ’17, ’17 a, ’17 b. McCollum, ’17. McCollum, ’18. McCollum, Simmonds and Parsons, ’18 a, ’19 a. McCollum and Simmonds, ’18 b. Mitchell and Mendel, ’21. Nelson, Heller and Fulmer, ’23. Osborne and Mendel, ’11, ’11 a, ’12 a, ’12 c, ’12 e, ’13 a, ’14, ’16 a, ’16 e, ’17 a, ’17 d, ’17 e, ’18, ’18 d, ’19 b, ’21 c. Pacini and Russell, ’18. Palmer and Kennedy, ’21. Richardson and Green, ’16, ’17, ’17 a. Sherman, Rouse, Allen and Woods, ’21. Steenbock, Kent and Gross, ’18. Steenbock, ’23. Sugiura and Benedict, ’18, ’19.

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*Reproduction and the sex organs.* Brumpt, '07. Carmichael and Marshall, '07. Corner and Hurni, '18. Corner and Warren, '19. Cuénot, 1899. Daels, '08. Evans and Bishop, '22, '22 a, '22 d, '23 b, '23 c. Fischel, '14. Freyer, '21. Hammett, '22 f. Heape, '00. Herring, '20. Ishii, '20, '22. Iwanoff, '03, '07. King, '16 a. Königstein, '07. Loew, '03. Lombroso and Bolaffio, '09. Long and Quisno, '16. Long, '19. Long and Evans, '20, '20 f, '22. Mattill and Conklin, '20. Mattill and Stone, '23. McCartney, '23. Osborne, Mendel and Ferry, '17. Palmer and Kennedy, '23. Przibram, '17. Reynolds and Macomber, '21. Scott and Evans, '21. Shimidzu, '20, '22. Slonaker and Card, '18, '23 c. Sobotta, '10. Steinach, '10. Stone, '22.

*Weight of ovaries during gestation and lactation.* Evans and Bishop, '23. King, '21. Long and Evans, '22. Stotsenburg, '23. *Male.* Ivanoff, '00. Moore, '23. Walker, '11. *Placenta.* Evans and Bishop, '22 b. *Uterus.* Blair, '23. Evans and Bishop, '22 c. Ogata, '21. Shimidzu, '20, '22. Tate and Clark, '22.

*Exocrine system: General.* Hashimoto, '22, '22 a. Laguesse and Castellant, 1898. Walker, '10, '10 a.

*Mammary function.* Frank and Unger, '11. Freyer and Evans, '23. Gage and Gage, '09. Hart, Nelson and Pitz, '18. Hartwell, '21, '21 a, '22. Kuramitsu and Loeb, '21 a. Loeb and Kuramitsu, '21. Lombroso and Bolaffio, '09. Maeder, '22. Myers, '19 a. Sutter, '21.

*Feeding exocrine glands.* Eddy, '16. Marine, '15.

*Endocrine system: General.* Biedl, '13. Degener, '22. Gies, '17. Goldmann, '09, '12. Hammett, '21. Itagaki, '17 b. Kojima, '17. McCartney, '23 a. Mingazzini, '01. Moore, '19, '19 a, '21. Sand, '19. Uno, '22. *Testes.* Barnabo, '13. Fisher, '23. Loisel, '04. Mattill and Carman, '23. Romeis, '21, '22. Steinach, 1894. Steinach and Holzknecht, '16. *Castration.* Donaldson and Hatai, '11 a. Gies and Miller, '17. *Transplantation.* Steinach, '11, '12. Yatsu, '21.

*Ovaries.* Bouin, 1899. Itagaki, '17, '17 a.

*Spaying.* Doncaster and Marshall, '10.

*Transplantation.* Marshall and Jolly, '07, '08. Steinach, '13. Stotsenburg, '17. Wiesner, '23.

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*Pineal.* Foà, '14.

*Hypophysis.* Degener, '22. Flower, Forkner, Kellum, Walker, Smith and Evans, '23. Gemelli, '06. Goetsch and Cushing, '13. Kojima, '17 a. Larson, '19, '20. Robertson and Burnett, '15. Schäfer, '09, '11.

*Thymus.* Jacobson, 1817. Pappenheimer, '14, '14 a, '14 b. Takenouchi, '19 a.

*Feeding endocrine glands. General.* Cameron, '23. Cleghorn, '01. Gies and Miller, '15. Gies and Heft, '17. Gudernatsch, '15 a, '18. Hewer, '14. Hoskins, '16. Kojima, '17 c. Schäfer, '12. Sisson and Finney, '20.

*Hypophysis.* Aldrich, '12, Behrenroth, '14. Evans and Long, '22. Goetsch, '16. Lewis and Miller, '13. Marinus, '19. Sandri, '08. Smith, '23.

*Thyroid.* Bircher, '10 a. Cameron and Carmichael, '20, '21, '21 a. Cameron and Moore, '21. Cameron and Sedziak, '21. Cameron and Carmichael, '22. Cameron, '23. Chidester, '12. Cramer and Krause, '13. Cramer and M'Call, '17, '19. Fordyce, '12. Gudernatsch, '15. Herring, '17, '17 a, '19. Hewitt, '14, '14 a, '20. Hoshimoto, '20. Kojima, '16, '17 b. Kuriyama, '17, '18, '18 a, '18 b. Peiser, '06.

*Suprarenals.* Hoskins and Hoskins, '16.

# CHAPTER 5

# GROWTH IN TOTAL BODY WEIGHT ACCORDING TO AGE

1. Introduction. 2. Growth before birth. 3. Growth between birth and maturity. 4. Weight-length ratio. 5. Modifications of growth in total body weight and organs. 6. Senescence.

1. *Introduction.* Under the general caption of growth several series of data are grouped in this chapter and in the four chapters which follow it. The chapter heads explain the several groupings and show that some data are presented according to age and other data according to some bodily measurement.

The reasons for this procedure will be evident in each instance. The effort has been made to gather as much of the data as possible under the caption of growth as this seemed the best way to make the records available for reference.

The following tables present the size, weight and composition of the albino rat and some of its parts, under conditions which may be considered normal.

As regards absolute measurements, it must be borne in mind that the Albino is very responsive to external conditions as represented by food, housing, temperature, exercise, and incidental disturbances, especially light and noises.

No two colonies today are kept under more than approximately similar conditions and it follows that the average size of the animals from different colonies varies. The conditions just noted also appear to influence the relative weights of some of the viscera. For these reasons, each set of determinations will be accompanied by a statement, as complete as possible, concerning the special conditions surrounding the animals on which the observations were made.

2. *Growth before birth.* For the data on growth during the first few days of fetal life, see Chapter 3, Embryology, early stages, p. 38, Huber ('15 a) and other references there given.

At about the 13th day after insemination the fetus is large enough to be directly weighed and from this date to birth the growth has been followed.

TABLE 118

*Showing the mean weights of the fetuses at ten ages during gestation and at birth Stotsenburg ('15)*

| AGE IN DAYS | NUMBER OF FETUSES | AVERAGE WEIGHT OF FETUSES IN GRAMS | RATE OF INCREASE IN WEIGHT |
|---|---|---|---|
| | | | *per cent* |
| 13 | 34 | 0.040 | |
| 14 | 44 | 0.112 | 179 |
| 15 | 37 | 0.168 | 50 |
| 16 | 44 | 0.310 | 83 |
| 17 | 21 | 0.548 | 77 |
| 18 | 43 | 1.000 | 83 |
| 19 | 30 | 1.580 | 58 |
| 20 | 25 | 2.630 | 65 |
| 21 | 42 | 3.980 | 51 |
| 22 | 10 | 4.630 | 16 |
| Strictly new born | 37 | 4.680 | |

TABLE 119

*Giving the crown-rump length of fetus in millimeters. Scrap diet only. The fetuses here measured are part of those used for Table 118*

| SERIAL NUMBER | AGE IN DAYS | NUMBER IN LITTER | AVERAGE WEIGHT OF FETUS | AVERAGE CROWN-RUMP LENGTH | RANGE OF LENGTH |
|---|---|---|---|---|---|
| | | | *grams* | *mm.* | *mm.* |
| 42 | 14 | 8 | 0.093 | 9.5 | 9.0–10.0 |
| 43 | 15 | 12 | 0.107 | 9.4 | 9.0–10.0 |
| 37 | 15 | 8 | 0.218 | 12.1 | 12.0–12.5 |
| 41 | 16 | 11 | 0.322 | 13.0 | 12.5–13.0 |
| 40 | 17 | 7 | 0.525 | 16.3 | 16.0–17.0 |
| 36 | 18 | 9 | 0.947 | 19.1 | 18.0–21.0 |
| 37 | 19 | 8 | 1.490 | 22.7 | 20.5–24.0 |
| 35 | 20 | 10 | 2.510 | 27.7 | 24.0–32.0 |
| 34 | 21 | 9 | 4.070 | 36.7 | 35.0–39.0 |
| 44 | 22 | 10 | 4.630 | 39.2 | 36.0–41.0* |

* This method of measurement gives a less length than the nose-anus method commonly used for the new born.

In a series of 38 females, each of which had already born one litter, Stotsenburg ('15) has observed exactly the time of insemination and then weighed the fetuses at the ages given in table 118. Before weighing the membranes were removed and in some instances the crown-rump length was measured (table 119). The graph representing the growth before birth from the 13th day on is given in chart 20 the interval used for one day being two-fifths of that used for 1 gram.

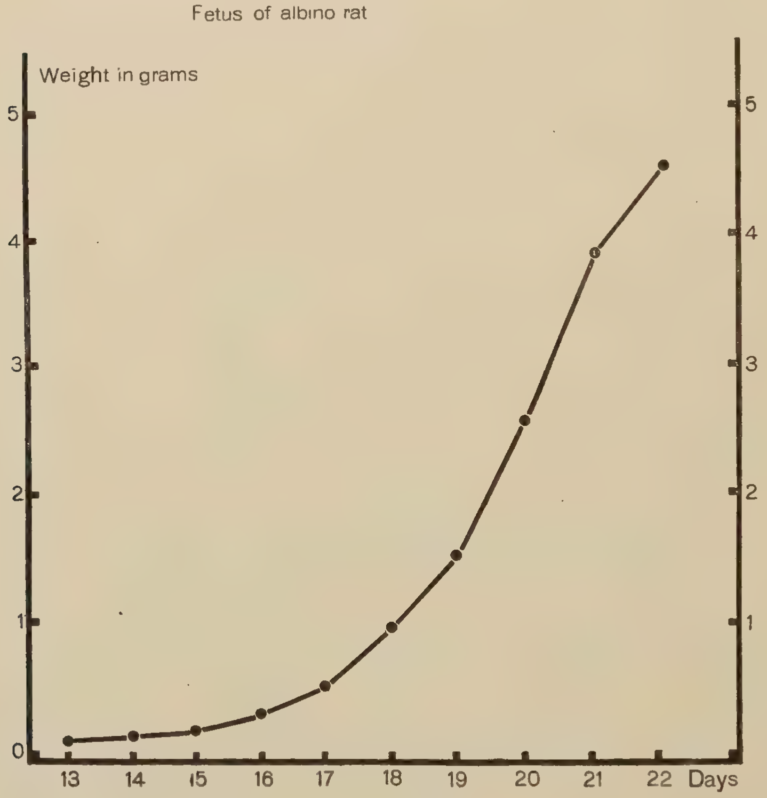

Chart 20 Shows the course of fetal growth from the 13th to the 22nd day gestation. The data are given in table 118.

3. *Growth between birth and maturity.* The first observations were made at the University of Chicago by Donaldson, Dunn and Watson ('06) on stock rats fed mainly on milk-soaked bread with corn as a staple. The values before fourteen days of age were obtained from weighing different litters, each litter being

weighed only once. The original values at birth and for the first ten days were plainly too high and have been replaced by new data (Donaldson, '15). After the 14th day the weighing of 19 males and 17 females was made at frequent intervals, so long as the animals kept in good condition.

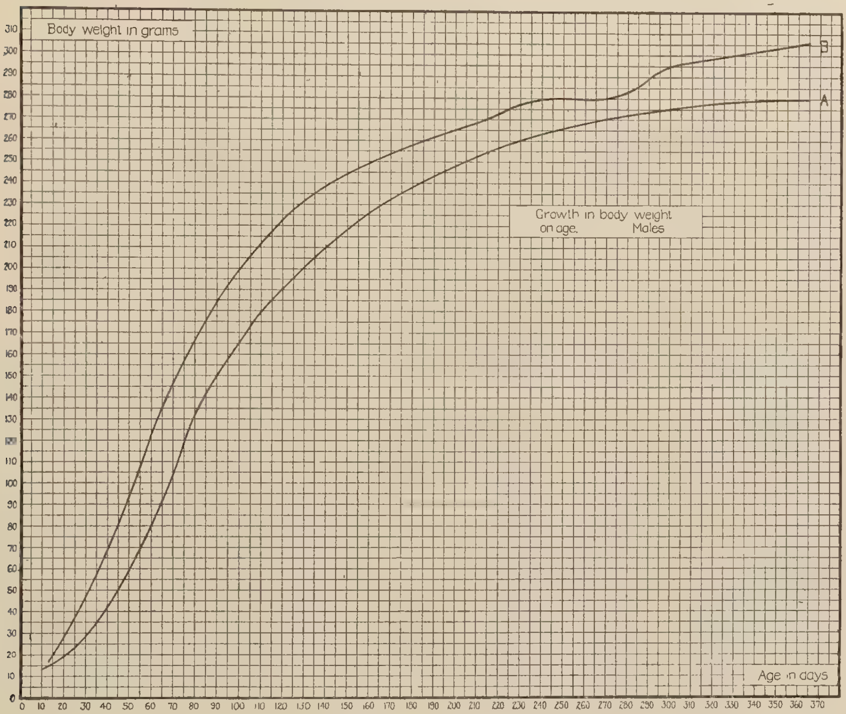

Chart 21 Growth in body weight on age. Male albino rat. *A*. Observations of Donaldson, Dunn and Watson ('06). See table 157. *B*. Observations of King ('15). Data from two series combined. See table 121.

Watson's ('05) observations show that mated females gain in weight about 0.03 per cent per diem faster than the unmated.

Using the data for graphs A in charts 21 and 22 Hatai has determined the graph for which formulas (41) and (42) give the values for the male, and formulas (43) and (44) the values for the female for this special series. By the use of these formulas the body weights have been computed for each day of age from 10 days on—see table 157.

The values given for the first ten days of age in table 157 have been obtained from a revised series of direct observations Donaldson ('15).

The weight at birth as here given, is for rats that have suckled.

Using a group of 148 males and 158 females, composed of animals which were specially well cared for and fed, Greeman and Duhring ('23, page 4, chart no. 1) have recorded a growth curve for the males which after a hundred days shows higher values than those just given. At 350 days this special group surpasses our male values by 65 grams and the curve is still rising.

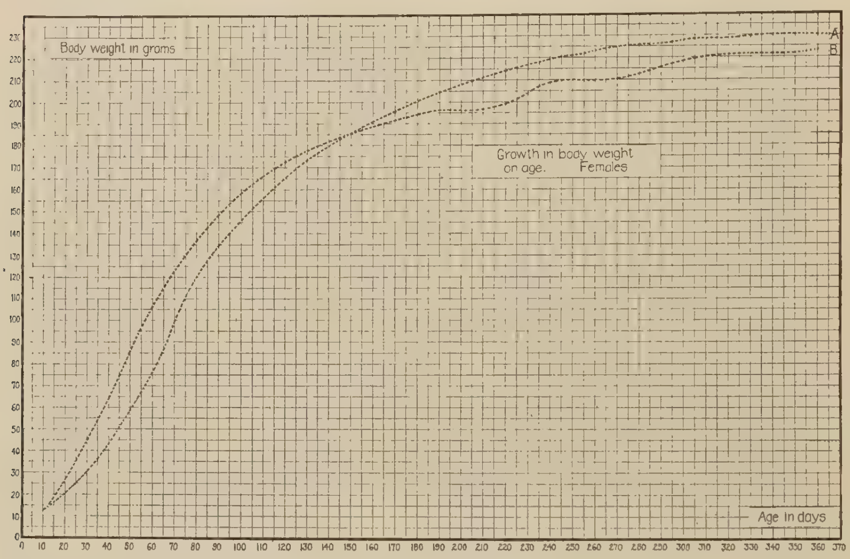

Chart 22 Growth of body weight on age. Female albino rat. *A*. Observations of Donaldson, Dunn and Watson ('06). See table 157. *B*. Observations of King ('15). Data from two series combined. See table 121.

In the case of the females the superior treatment and food produce animals which are about 15 grams heavier at 100 days and about 18 grams heavier at 350 days. As so often happens the greater response is given by the males—table 157 a.

Finally at The Institute, King ('15 a) has conducted two series of observations (1912–1913) (1913–1915) on the increase in body weight with age in stock Albinos. There were 23 males and 23 females in the first series and 27 of each sex in the second. The records for the two series have been combined. The observations extend from 13-485 days and the weighings were made at the ages given in table 120. These rats received a "scrap" diet (i.e., a diet composed of selected table scraps).

TABLE 120

*Data on thirteen litters of stock albino rats, showing the increase in the weight of the body with age*

| AGE IN DAYS | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | Body weight in grams | | | Number of individuals | Body weight in grams | | | Number of individuals |
| | Average | Lowest | Highest | | Average | Lowest | Highest | |
| 13..... | 17.2 | 13 | 21 | 50 | 15.7 | 13 | 20 | 67 |
| 30..... | 48.5 | 41 | 60 | 50 | 45.7 | 39 | 57 | 50 |
| 60..... | 122.9 | 64 | 170 | 50 | 107.1 | 66 | 153 | 50 |
| 90..... | 184.8 | 103 | 238 | 50 | 148.0 | 95 | 178 | 39 |
| 120..... | 223.2 | 146 | 284 | 50 | 173.4 | 125 | 212 | 42 |
| 151..... | 244.8 | 169 | 307 | 50 | 186.3 | 147 | 225 | 45 |
| 182..... | 258.4 | 172 | 343 | 50 | 196.5 | 147 | 245 | 42 |
| 212..... | 268.0 | 176 | 366 | 48 | 197.3 | 136 | 245 | 42 |
| 243..... | 279.7 | 194 | 355 | 44 | 209.6 | 141 | 256 | 43 |
| 273..... | 280.9 | 202 | 349 | 41 | 210.8 | 158 | 254 | 38 |
| 304..... | 296.1 | 198 | 379 | 36 | 219.1 | 165 | 262 | 38 |
| 334..... | 300.8 | 238 | 385 | 33 | 222.4 | 170 | 276 | 35 |
| 365..... | 306.1 | 245 | 377 | 28 | 223.1 | 176 | 276 | 31 |
| 395..... | 314.1 | 246 | 381 | 24 | 220.5 | 175 | 284 | 31 |
| 425..... | 312.2 | 243 | 397 | 23 | 215.8 | 169 | 271 | 30 |
| 455..... | 323.9 | 249 | 414 | 15 | 220.2 | 196 | 264 | 18 |
| 485..... | 326.0 | 255 | 437 | 12 | 234.7 | 197 | 324 | 13 |

In chart 21 the record for the males is given by graph B and in chart 22 the record for the females by graph B.

Table 121 gives also the coefficient of variation in body weight for each sex. The average value for the coefficient of variation is for males 13.6 and for females 12.1. In table 141 the fraternal variability for each sex is recorded. As there shown, the fraternal variability is for both sexes less than that for the general population.

TABLE 121

*Giving the increase in body weight with age—stock Albinos. Mean of two series—King ('15 a) and giving also the coefficients of variation with their probable errors. The Wistar Institute Colony.*

| MALES | | | | FEMALES | | |
|---|---|---|---|---|---|---|
| Age in days | Number of individuals | Average body weight | Coefficient of variation | Number of individuals | Average body weight | Coefficient of variation |
| | | *grams* | | | *grams* | |
| 13 | 50 | 17.2 | 11.8±0.795 | 50 | 15.7 | 11.4±0.768 |
| 30 | 50 | 48.5 | 10.2±0.687 | 50 | 45.7 | 11.0±0.741 |
| 60 | 50 | 122.9 | 17.0±1.140 | 50 | 107.1 | 15.7±1.050 |
| 90 | 50 | 184.8 | 14.8±0.998 | 39 | 148.0 | 12.5±0.951 |
| 120 | 50 | 223.2 | 13.4±0.903 | 42 | 173.4 | 10.3±0.755 |
| 151 | 50 | 244.8 | 13.3±0.896 | 45 | 186.3 | 10.4±0.735 |
| 182 | 50 | 258.4 | 14.2±1.220 | 42 | 196.5 | 12.3±0.903 |
| 212 | 48 | 268.0 | 14.0±0.964 | 42 | 197.3 | 12.4±0.910 |
| 243 | 44 | 279.7 | 13.9±0.998 | 43 | 209.6 | 12.6±0.910 |
| 273 | 41 | 280.9 | 13.4±0.997 | 38 | 210.8 | 11.5±0.890 |
| 304 | 36 | 296.1 | 14.0±1.110 | 38 | 219.1 | 10.3±0.795 |
| 334 | 33 | 300.8 | 13.7±1.130 | 35 | 222.4 | 10.8±0.870 |
| 365 | 28 | 306.1 | 13.0±1.160 | 31 | 223.1 | 10.7±0.910 |
| 395 | 24 | 314.1 | 12.6±1.220 | 31 | 220.5 | 11.5±0.984 |
| 425 | 23 | 312.2 | 13.4±1.320 | 30 | 215.8 | 10.9±0.944 |
| 455 | 15 | 323.9 | 13.6±1.670 | 18 | 220.2 | 8.9±0.998 |
| 485 | 12 | 326.0 | 15.0±2.060 | 13 | 234.7 | 13.4±1.770 |

TABLE 122

*Giving in grams the values obtained by dividing the body weight by body length in millimeters. Based on data in table 144*

| BODY LENGTH | RATIO | | BODY LENGTH | RATIO | | BODY LENGTH | RATIO | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | | Male | Female | | Male | Female |
| *mm.* | | | *mm.* | | | *mm.* | | |
| 50 | 0.10 | 0.10 | 110 | 0.32 | 0.34 | 180 | 0.76 | 0.82 |
| 55 | 0.11 | 0.11 | 120 | 0.36 | 0.38 | 190 | 0.86 | 0.92 |
| 60 | 0.13 | 0.13 | 130 | 0.41 | 0.44 | 200 | 0.97 | 1.05 |
| 70 | 0.16 | 0.17 | 140 | 0.47 | 0.50 | 210 | 1.10 | 1.19 |
| 80 | 0.20 | 0.21 | 150 | 0.53 | 0.56 | 220 | 1.24 | 1.34 |
| 90 | 0.24 | 0.25 | 160 | 0.60 | 0.64 | 230 | 1.40 | 1.52 |
| 100 | 0.28 | 0.29 | 170 | 0.67 | 0.71 | 240 | 1.58 | 1.73 |
| | | | | | | 250 | 1.79 | 1.97 |

4. *Weight-length ratio.* Using the values for body weight and body length, as given in table 144 the weight value for a running

millimeter has been determined for each sex, table 122—at a series of selected body lengths; values for intervening lengths may be had by interpolation. After 60 mm. in body length the ratio for the female is higher than that for the male. By the use of this table it can be determined whether a given rat is emaciated or fat.

5. *Modifications of growth in total body weight and organs.* The foregoing data on growth on age represent the usual results under moderately favorable conditions. By improvement in the food and other conditions, more rapid and greater final growth can be obtained (Greenman and Duhring, '23). Most investigators at the present time carry a series of litter controls with which their test rats are compared, and this should be done wherever possible. It is to be kept in mind that the usual results run much closer to the maximum than to the minimum, i. e., it is much easier to retard and reduce the growth of the rat than it is to accelerate or increase it. Thus, in a sense, slight gains are equivalent to large losses.

Body growth is better after lecithin feeding (Hatai, '03 a) and with various forms of abundant and varied diets. Increased growth occurs in spayed females (Stotsenburg, '13) due in part to the formation of fat.

Bearing young increases the body weight of the female (J. B. Watson, '05). Some young, undersized at birth, also grow more rapidly than their litter mates (King, '16). Exercise improves growth (Donaldson 'MS.).

Body growth is poorer under starvation conditions and with all forms of defective, deficient or monotonous diets. Isolated animals grow less well than those kept together. Disturbed surroundings, visitors or change of the caretaker cause arrests in growth or even losses in weight.

The effect on body growth of the removal of the thyroid and parathyroid glands (Hammett, '23) is given on page 162.

Body growth is not affected by castration (Stotsenburg, '09) nor by either single or double "isolation" of the ovaries within the rat, despite the fact that in double isolation the ovaries are much atrophied, while in single isolation the surviving ovary is hypertrophied—Stotsenburg ('17).

6. *Senescence.* In the colony at the Institute albino rats rarely live more than 40 months. Commonly lung disease (rat pneumonia) is the immediate cause of death. After two years the animals tend to become slow and decrepit. They eat less, sleep much and the hair become thin, rough and dry. The angle between the nasal and frontal bones is increased, giving the "roman nose" effect. The female usually ceases to breed at 18 to 20 months. The end of the breeding time in the males is not known. The loss in body weight in old animals is very marked, but whether body length is also diminished is not known.

As shown in table 156 and chart 49–Nos. 1–21 the relative weights of the organs decrease with advancing age, but just how great this decrease may be in rats, three years old or older, has yet to be determined.

## GROWTH IN TOTAL BODY WEIGHT ACCORDING TO AGE: REFERENCES

*Introduction.* Przibram, '22.

*Growth before birth.* Huber, '15 a. Stotsenburg, '15.

*Growth between birth and maturity.* Donaldson, '06, '12 c, '15. Donaldson, Dunn and Watson, '06. Dunn, '08. Ferry, '13. Greenman and Duhring, '23. Jackson, '13, King, '15, '15 a. Robertson, '08. Watson, '05.

*Modifications of growth in total body weight and in organs.* Donaldson, '11 a. Greenman and Duhring, '23. Hammett, '23. Hart and McCollum, '13, '14. Hatai, '03 a, '04 a, '07 a, '08, '13 a, '15, '15 b. Henn, '20. Jackson, '15, '15 a, '15 b. Jackson and Stewart, '18, '19, '20. King, '16. Kudo, '21, '21 a. Morgulis, '11. Osborne and Mendel, '14 d, '15 d, '16. Paul, '06. Reed, '21. Slonaker and Card, '23. Smith and Ascham, '22. Stewart, '16, '18, '19. Stotsenburg, '09, '13, '17. Watson, '06, '06 a, '06 b. Watson and Gibbs, '06. Watson and Lyon, '06. Watson, '07 a, '07 b, '07 c, '07 d, '10, '12. Watson, J. B., '05.

*Senescence.* Ruzicka, '22.

# CHAPTER 6

# GROWTH OF PARTS AND SYSTEMS OF THE BODY IN WEIGHT

1. Larger divisions. 2. Systems. 3. Teeth. 4. Blood. 5. Fat.

1. *Larger divisions.* The relative growth of the component parts (head, trunk and limbs) and of the systems (integument ligamentous skeleton, musculature and viscera) has been studied by Jackson and Lowrey ('12).

The rats were reared at the University of Missouri and fed daily with wheat bread soaked in whole milk—a supply of chopped corn being kept constantly in the cages. In addition fresh beef was given once a week. The rats were well grown except at five months and one year, when both sexes were somewhat low in body weight—the deficiency being most marked in the females.

The report of the work by Jackson and Lowrey ('12) is given largely in their own words.

The method of dissection was as follows. The animal was taken in the morning before feeding and killed by chloroform. The gross body weight, and the lengths of body and tail were recorded. The head (with skin) was then removed (just posterior to the foramen magnum and anterior to the larynx) and weighed. In the meantime, the trunk was suspended and the blood (unmeasured) was allowed to escape. Then the viscera were carefully removed and weighed individually (including brain, spinal cord, eyeballs, thyroid, thymus, heart, lungs, liver, spleen, stomach and intestines, both with contents and empty, suprarenals, kidneys and gonads). Urine was estimated if present. The extremities were separated at the shoulder and hip joints and weighed with skin. The skin (including ears, claws and adherent subcutaneous tissue) was next removed and weighed. The trunk weight was estimated by subtracting the weight of the head and extremities from the net body weight.

Then the musculature with skeleton was weighed, the few remaining additional structures (genitalia, large vessels, pharynx and oesophagus, larynx and trachea, and masses of fat connected with the musculature) having been carefully removed. Finally the musculature was carefully dissected off and the skeleton, including bones, cartilages and ligaments, was weighed. This weight, subtracted from that of the skeleton and musculature together, gives the weight of the musculature, including the tendons. Evaporation was reduced to a minimum by keeping the various structures in a closed moist container, so far as possible. *The net body weight, which is the gross body weight minus contents of stomach, intestines and urinary bladder, was used as the basis in calculating the percentage weights.* The percentages therefore differ slightly from those calculated upon the gross body weight. The difference is not of material importance in the case of the albino rat, however, as the intestinal and other contents do not average more than 5 per cent of the body at the ages observed (excepting at 6 weeks, where the average was about 8 per cent). The observations were grouped at seven ages, chosen for the following reasons. At one week the weight at birth has about doubled. At three weeks it has about doubled again, and this moreover is the age at which the animal is usually weaned. At six weeks the body weight has again about doubled, and the animal is well established upon its permanent diet. Ten weeks represents the age of puberty, and the body weight of six weeks has again about doubled. At one year the body weight has again nearly doubled, and this represents nearly the adult weight. Five months was arbitrarily selected as the time when the body weight is approximately half way between those of ten weeks and one year. While therefore observations are not available for the various intermediate age periods, these are sufficiently close together so that no important change in the relative weights of the constituent parts is likely to be overlooked. Moreover, on account of the variations at the different ages in the body weights, these form a fairly continuous series; and the relative weights of the various constituent parts are apparently more closely correlated with the body weight than with the age.

The relative weights of the component parts examined are given in table 123 (modified from table 2, p. 455, loc. cit.).

The authors point out that the maximum relative weight is shown by the head at one week, by the forelimbs at three weeks, by the hind limbs at five months and by the trunk at a year—the wave of most active growth thus passing from the head caudad with advancing age.

The body weights in table 123 are for the rats—three or less of each sex at each age—on which the percentage weights of the fore and hind limbs were determined. The values for the head and the trunk are based on a series of twenty or more rats for each sex at each age.

2. *Systems.* The relative growth of the various systems is also given for the integument, ligamentous skeleton, musculature and viscera. The method of preparing each system and the series of organs here comprising the viscera have been previously noted (p. 182). The following table 124 is based on table 4 (loc. cit., p. 460) to which has been added the average values of the net body weights.

It is to be noted that the percentages in tables 123 and 124 are based on the "net body weight" of the rats. According to Jackson and Lowrey this is about 95 per cent of the gross weight, and this factor can be used therefore to transform net into gross weight.

TABLE 123

*Albino rat—Average percentage weight of head, trunk and extremities all with skin, at various ages—sexes combined (Jackson and Lowrey, '12)*

| AGE, DAYS | BODY WEIGHT NET | HEAD | FORE-LIMBS | HIND-LIMBS | TRUNK |
|---|---|---|---|---|---|
| | *grams* | *per cent* | *per cent* | *per cent* | *per cent* |
| 0 | 5.4 | 21.65 | 7.39 | 9.45 | 61.51 |
| 7 | 11.6 | 23.70 | 8.92 | 11.97 | 55.41 |
| 21 | 25.5 | 20.22 | 9.25 | 14.87 | 55.66 |
| 42 | 79.2 | 11.80 | 6.72 | 14.94 | 66.54 |
| 70 | 141.9 | 9.56 | 5.32 | 15.59 | 69.53 |
| 150 | 190.7 | 9.42 | 5.87 | 15.64 | 69.07 |
| 365 | 222.2 | 9.29 | 4.76 | 14.63 | 71.32 |

Jackson and Lowrey conclude (p. 472) that their data indicate no noteworthy differences between the sexes in the relative weights of the various parts and systems, and that the body of the albino rat has practically reached the adult proportions in several of its component parts and systems at the age of ten weeks.

Corresponding observations, though less extensive, made on the Norway rat are given in chapter 13.

*The Skeleton.* (*a*) *Ligamentous Skeleton.* Since the values for the skeleton as given in table 124 were obtained by the dissection of the soft parts from the bones it is evident that the "ligamentous skeleton" thus prepared would have a greater weight than the "cartilaginous skeleton" prepared by maceration.

Owing to the completeness of the preparation by the latter method, it was deemed desirable to study the skeleton in this way and some of the data obtained for the cartilaginous skeleton by Donaldson and Conrow ('19) are here introduced.

(*b*) *Cartilaginous skeleton. Weight of entire cartilaginous skeleton.* Using a 2 per cent solution of the commercial gold dust washing powder ("gold dust washing powder" consists of about 45 per cent sodium carbonate, 30 per cent soap powder, and 25 per cent water), the skeletons of some 106 Albinos have been carefully prepared at The Institute (Donaldson and Conrow, '19). The animals were reared on a scrap diet.

TABLE 124

*Average percentage weights of integument, ligamentous skeleton, musculature, viscera and remainder. Based on Jackson and Lowrey ('12), table 4. For the corresponding absolute weights see table 125*

| AGE IN DAYS | SEX AND NUMBER | BODY WEIGHT | PERCENTAGE VALUES—SEXES COMBINED FOR | | | | |
|---|---|---|---|---|---|---|---|
| | | | Integument | Ligamentous skeleton | Musculature | Viscera | Remainder |
| | | *grams* | | | | | |
| 0 | M. 9<br>F. 9 | 4.7 | 19.8 | 17.3 | 24.4 | 18.1 | 20.4 |
| 7 | M. 8<br>F. 11 | 10.1 | 25.9 | 18.5 | 22.8 | 19.2 | 13.6 |
| 21 | M. 7<br>F. 6 | 24.8 | 22.4 | 16.6 | 26.9 | 21.3 | 12.8 |
| 42 | M. 6<br>F. 8 | 64.5 | 20.9 | 14.0 | 32.7 | 20.4 | 12.0 |
| 70 | M. 5<br>F. 5 | 130.5 | 18.7 | 11.7 | 41.1 | 16.0 | 12.5 |
| 150 | M. 6<br>F. 7 | 184.3 | 18.1 | 11.5 | 42.6 | 14.8 | 13.0 |
| 365 | M. 4<br>F. 2 | 234.6 | 18.0 | 10.9 | 45.4 | 13.3 | 12.4 |

The weight of the skeleton is given in relation to the body weight. The value for the body used here is that normal to the body length (see table 144) when the observed body weight is less than that to be expected—but the observed body weight is used when that is above the normal for the body length. In the case of old rats undergoing senile loss of body weight the *maximum body weight* is the one used.

The weight of the teeth is included with that of the skeleton but the weight of the nails is excluded.

The data are for both sexes combined.

TABLE 125

*Shows for the series of body weights of the albino rat by Jackson and Lowrey ('12) the absolute weights of integument, ligamentous skeleton, musculature, viscera and remainder determined by the use of the percentage values given in the preceding table 124.*

| AGE IN DAYS | MEAN BODY WEIGHTS | SEX NUMBER | INTEGUMENT | LIGAMENTOUS SKELETON | MUSCULATURE | VISCERA | REMAINDER |
|---|---|---|---|---|---|---|---|
| | | | *grams* | *grams* | *grams* | *grams* | *grams* |
| 0 | Average M. + F. | | | | | | |
| | 5.11 | M. 9 | 1.00 | 0.87 | 1.19 | 0.90 | 1.15 |
| | 4.27 | F. 9 | 0.85 | 0.75 | 1.09 | 0.79 | 0.79 |
| | 4.69 | | 0.93 | 0.81 | 1.15 | 0.85 | 0.97 |
| 7 | 10.47 | M. 8 | 2.79 | 1.93 | 2.40 | 2.00 | 1.36 |
| | 9.83 | F. 11 | 2.33 | 1.70 | 2.24 | 1.90 | 1.30 |
| | 10.10 | | 2.62 | 1.87 | 2.30 | 1.94 | 1.37 |
| 21 | 26.91 | M. 7 | 6.35 | 4.20 | 7.45 | 5.71 | 3.23 |
| | 22.31 | F. 6 | 4.69 | 3.97 | 5.78 | 4.77 | 3.08 |
| | 24.78 | | 5.55 | 4.11 | 6.67 | 5.28 | 3.17 |
| 42 | 60.10 | M. 6 | 12.14 | 9.08 | 19.41 | 12.86 | 6.67 |
| | 67.80 | F. 8 | 14.51 | 8.95 | 22.37 | 13.36 | 8.61 |
| | 64.50 | | 13.48 | 9.03 | 21.09 | 13.16 | 7.74 |
| 70 | 143.60 | M. 5 | 26.14 | 15.94 | 57.15 | 23.26 | 21.11 |
| | 117.50 | F. 5 | 22.56 | 14.34 | 49.94 | 18.68 | 11.99 |
| | 130.50 | | 24.40 | 15.27 | 53.64 | 20.88 | 16.31 |
| 150 | 218.70 | M. 6 | 41.99 | 22.84 | 93.38 | 29.96 | 25.52 |
| | 154.80 | F. 7 | 26.62 | 18.73 | 65.94 | 24.30 | 19.20 |
| | 184.30 | | 33.36 | 21.38 | 78.51 | 27.28 | 23.77 |
| 365 | 260.20 | M. 4 | 44.75 | 25.50 | 120.99 | 33.83 | 35.13 |
| | 183.50 | F. 2 | 35.78 | 24.22 | 79.46 | 25.32 | 18.72 |
| | 234.60 | | 42.23 | 25.57 | 106.51 | 31.20 | 29.09 |

*Correction for sex.* For a given body weight the female as compared with the male as a standard has slightly shorter and lighter bones. For a given body length, slightly heavier bones. The exact values for correction cannot be given at present, but in making any allowance for sex, it must be remembered that the table data are for the sexes combined, and hence intermediate in value.

The moist or fresh determinations here recorded were made just after preparation. The room dried values mentioned later are for material kept in the laboratory in open but dust free vessels at 17°–23°C. for thirty days, while the oven dried values are for material heated to 96°C. for seven days before weighing.

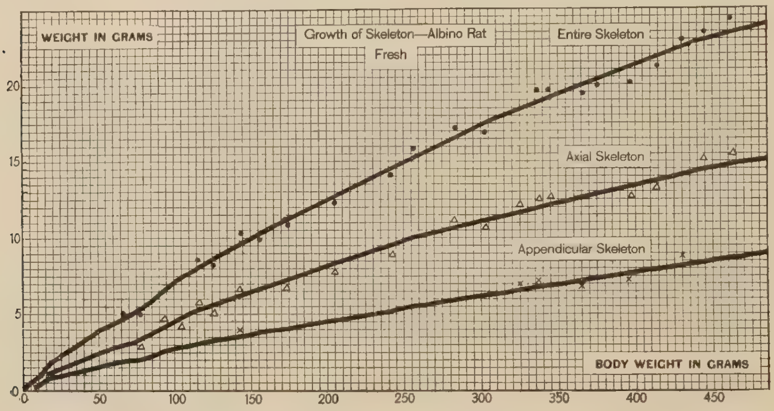

Chart 23 Absolute fresh weight of entire skeleton, axial skeleton, and appendicular skeleton in grams, on the body weight (albino rat). Table 126.
● Entire skeleton. Δ Axial skeleton. × Appendicular skeleton.

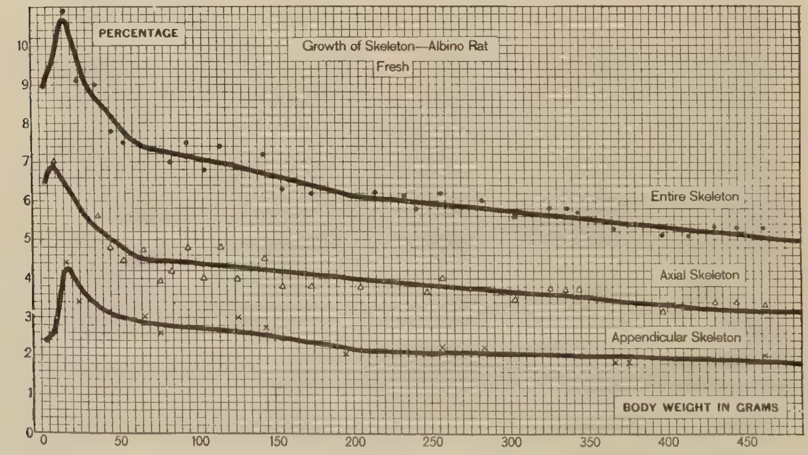

Chart 24 Relative fresh weight of entire skeleton, axial skeleton, and appendicular skeleton, on body weight (albino rat). Table 126.
● Entire skeleton. Δ Axial skeleton. × Appendicular skeleton.

The data on the percentage of water in the skeleton and its parts are given in chapter 8.

Some selected results, entered in forty-two body weight groups, appear in tables 126–131 and Charts 23, 24 and 25.

Table 126 gives the fresh weights of the entire skeleton and its main divisions on body weight—Charts 23 and 24.

If the percentage weight of the "ligamentous" skeleton for the extremes of body weight as given in table 124 is compared with that for the "cartilaginous" skeleton, table 126, it appears that at a body weight of five grams the cartilaginous skeleton represents only 53 per cent of the value for the ligamentous skeleton, while at 235 grams it represents about the same or 55 per cent. Roughly then the proportional weight of the ligamentous is nearly twice that of the cartilaginous skeleton, obtained by this method of maceration. We shall not attempt to adjust these two sets of values, but in table 127 are given the factors for correction of the macerated (cartilaginous) skeleton by which the effect of the maceration can be corrected and the true weight can be fairly approximated.

It appears from this table that the loss in fresh weight drops from about 16 per cent at birth to about 7.5 per cent at a body weight of 100 grams, and after a body weight of 200 grams the weight of the macerated may be below that of the unmacerated bones—from 4.5 to 3.5 per cent. When, however, the oven-dried weights of these same bones are compared, it is seen that while the losses after oven-drying follow the same course as was followed in the case of the fresh bones, yet the values run very consistently—about 3 to 3.4 per cent (on the average) below those for the fresh bones.

As the long bones of the limbs are most readily prepared, and as their condition appears to indicate that of the skeleton in general, several tables giving data for them are presented. Table 128 and Chart 25 give the absolute weight of the fresh limb bones on body weight. The corresponding weights for the room

TABLE 126

*Absolute and relative fresh weights of entire skeleton, axial skeleton, and appendicular skeleton, on body weight. From smoothed graphs in charts 23 and 24*

| BODY WEIGHT | FRESH SKELETON WEIGHT | WEIGHT OF FRESH SKELETON ON BODY WEIGHT | AXIAL FRESH WEIGHT | FRESH AXIAL ON FRESH BODY WEIGHT | APPENDICULAR FRESH WEIGHT | FRESH APPENDICULAR ON BODY WEIGHT |
|---|---|---|---|---|---|---|
| *grams* | *grams* | *per cent* | *grams* | *per cent* | *grams* | *per cent* |
| 5 | 0.46 | 9.20 | 0.34 | 6.70 | 0.12 | 2.50 |
| 10 | 0.99 | 9.90 | 0.69 | 6.87 | 0.30 | 3.03 |
| 15 | 1.59 | 10.61 | 0.98 | 6.53 | 0.61 | 4.08 |
| 20 | 2.06 | 10.30 | 1.24 | 6.20 | 0.82 | 4.10 |
| 25 | 2.40 | 9.60 | 1.48 | 5.90 | 0.92 | 3.70 |
| 30 | 2.70 | 9.01 | 1.68 | 5.59 | 1.02 | 3.42 |
| 35 | 3.06 | 8.73 | 1.87 | 5.33 | 1.19 | 3.40 |
| 40 | 3.39 | 8.47 | 2.08 | 5.20 | 1.31 | 3.27 |
| 45 | 3.69 | 8.20 | 2.26 | 5.03 | 1.43 | 3.17 |
| 50 | 4.00 | 8.00 | 2.44 | 4.88 | 1.56 | 3.12 |
| 55 | 4.27 | 7.77 | 2.62 | 4.77 | 1.65 | 3.00 |
| 60 | 4.54 | 7.57 | 2.76 | 4.60 | 1.78 | 2.97 |
| 65 | 4.83 | 7.43 | 2.94 | 4.53 | 1.89 | 2.90 |
| 70 | 5.16 | 7.37 | 3.15 | 4.50 | 2.01 | 2.87 |
| 75 | 5.48 | 7.30 | 3.35 | 4.47 | 2.13 | 2.83 |
| 80 | 5.82 | 7.27 | 3.55 | 4.44 | 2.27 | 2.83 |
| 85 | 6.12 | 7.20 | 3.75 | 4.41 | 2.37 | 2.79 |
| 90 | 6.48 | 7.20 | 3.96 | 4.40 | 2.52 | 2.80 |
| 95 | 6.81 | 7.17 | 4.18 | 4.40 | 2.63 | 2.77 |
| 100 | 7.10 | 7.10 | 4.39 | 4.39 | 2.71 | 2.71 |
| 110 | 7.71 | 7.01 | 4.79 | 4.35 | 2.92 | 2.66 |
| 120 | 8.33 | 6.94 | 5.16 | 4.30 | 3.17 | 2.64 |
| 130 | 8.93 | 6.87 | 5.55 | 4.27 | 3.38 | 2.60 |
| 140 | 9.48 | 6.77 | 5.91 | 4.22 | 3.57 | 2.55 |
| 150 | 10.00 | 6.67 | 6.30 | 4.20 | 3.70 | 2.47 |
| 160 | 10.51 | 6.57 | 6.69 | 4.18 | 3.82 | 2.39 |
| 170 | 11.00 | 6.47 | 7.02 | 4.13 | 3.98 | 2.34 |
| 180 | 11.47 | 6.37 | 7.33 | 4.07 | 4.14 | 2.30 |
| 190 | 11.84 | 6.23 | 7.66 | 4.03 | 4.18 | 2.20 |
| 200 | 12.34 | 6.17 | 8.00 | 4.00 | 4.34 | 2.17 |
| 210 | 12.81 | 6.10 | 8.38 | 3.99 | 4.43 | 2.11 |
| 220 | 13.31 | 6.05 | 8.71 | 3.96 | 4.60 | 2.09 |
| 230 | 13.80 | 6.00 | 8.99 | 3.91 | 4.81 | 2.09 |
| 240 | 14.35 | 5.98 | 9.34 | 3.89 | 5.01 | 2.09 |
| 250 | 14.83 | 5.93 | 9.63 | 3.85 | 5.20 | 2.08 |
| 270 | 15.80 | 5.85 | 10.21 | 3.78 | 5.59 | 2.07 |
| 290 | 16.76 | 5.78 | 10.79 | 3.72 | 5.97 | 2.06 |
| 310 | 17.58 | 5.67 | 11.22 | 3.62 | 6.36 | 2.05 |
| 330 | 18.48 | 5.60 | 11.85 | 3.59 | 6.63 | 2.01 |
| 350 | 19.32 | 5.52 | 12.36 | 3.53 | 6.96 | 1.99 |
| 370 | 20.02 | 5.41 | 12.65 | 3.42 | 7.37 | 1.99 |
| 390 | 20.94 | 5.37 | 13.22 | 3.39 | 7.72 | 1.98 |
| 410 | 21.61 | 5.27 | 13.53 | 3.30 | 8.08 | 1.97 |
| 430 | 22.32 | 5.19 | 13.89 | 3.23 | 8.43 | 1.96 |
| 450 | 22.95 | 5.10 | 14.40 | 3.20 | 8.55 | 1.90 |
| 470 | 23.55 | 5.01 | 14.95 | 3.18 | 8.60 | 1.83 |
| 485 | 24.20 | 4.99 | 15.37 | 3.17 | 8.83 | 1.82 |

TABLE 127

*Factors for correction*

*Percentage of loss in weight of bones after macerating in 2 per cent "Gold Dust Washing Powder." Based on the combined data for the humerus and femur. Entered according to body weight for each sex*

| BODY WEIGHT | LOSS—MALES | | LOSS—FEMALES | |
|---|---|---|---|---|
| | Fresh | Oven-dried | Fresh | Oven-dried |
| *grams* | *per cent* | *per cent* | *per cent* | *per cent* |
| 5 | 15.85 | 12.85 | 15.70 | 12.70 |
| 10 | 14.30 | 11.40 | 14.40 | 11.40 |
| 15 | 13.40 | 10.45 | 13.45 | 10.45 |
| 20 | 12.35 | 9.10 | 12.65 | 9.50 |
| 25 | 11.70 | 8.50 | 11.95 | 8.75 |
| 30 | 11.05 | 8.00 | 11.35 | 8.25 |
| 35 | 10.65 | 7.60 | 10.85 | 7.80 |
| 40 | 10.20 | 7.20 | 10.40 | 7.40 |
| 45 | 9.85 | 6.90 | 10.00 | 7.00 |
| 50 | 9.50 | 6.70 | 9.65 | 6.65 |
| 55 | 9.30 | 6.35 | 9.30 | 6.40 |
| 60 | 9.00 | 6.05 | 8.95 | 6.10 |
| 65 | 8.70 | 5.85 | 8.65 | 5.80 |
| 70 | 8.55 | 5.65 | 8.50 | 5.55 |
| 75 | 8.35 | 5.40 | 8.25 | 5.25 |
| 80 | 8.20 | 5.15 | 8.05 | 5.00 |
| 85 | 8.05 | 4.95 | 7.85 | 4.70 |
| 90 | 7.85 | 4.70 | 7.65 | 4.55 |
| 95 | 7.70 | 4.60 | 7.45 | 4.35 |
| 100 | 7.50 | 4.40 | 7.30 | 4.15 |
| 110 | 7.20 | 4.10 | 7.00 | 3.75 |
| 120 | 7.00 | 3.80 | 6.70 | 3.40 |
| 130 | 6.70 | 3.50 | 6.40 | 2.95 |
| 140 | 6.50 | 3.15 | 5.80 | 2.30 |
| 150 | 6.20 | 2.60 | 5.35 | 1.85 |
| 160 | 5.80 | 2.25 | 4.95 | 1.45 |
| 170 | 5.40 | 1.90 | 4.55 | 1.15 |
| 180 | 5.10 | 1.55 | 4.15 | 0.70 |
| 190 | 4.70 | 1.30 | 3.90 | 0.50 |
| 200 | 4.45 | 1.05 | 3.60 | 0.25 |
| 210 | 4.20 | 0.75 | 3.45 | 0.08 |
| 220 | 4.00 | 0.55 | | |
| 230 | 3.80 | 0.35 | | |
| 240 | 3.60 | 0.20 | | |
| 250 | 3.45 | 0.10 | | |

dried bones are given in table 129. Table 130 gives the absolute length of the fresh limb bones on body weight—also Chart 25a and table 131 gives the same on body length.

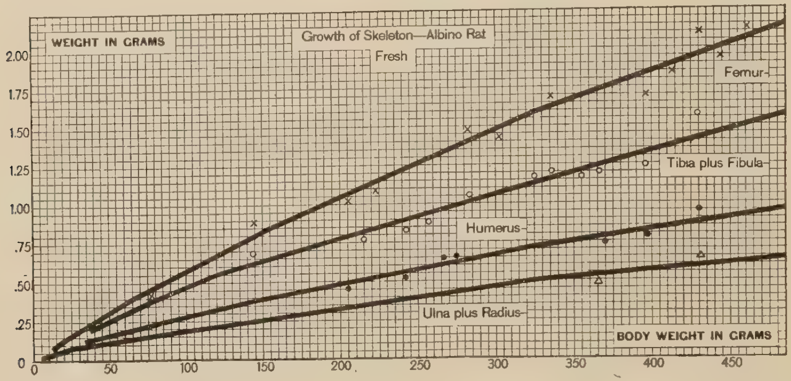

Chart 25 Absolute weight of the fresh limb bones, on body weight (albino rat). Table 128.

× Femur. ○ Tibia plus fibula. ● Humerus. Δ Ulna plus radius.

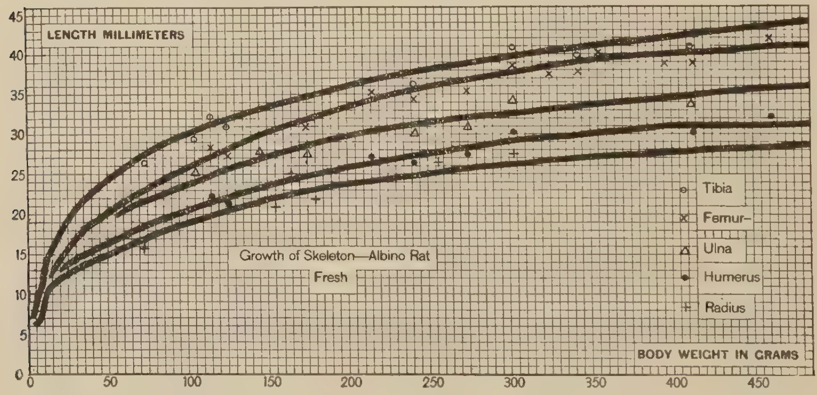

Chart 25a. Length of fresh limb bones in millimeters, on body weight (albino rat.) Table 130.

○ Tibia. × Femur. Δ Ulna. ● Humerus. + Radius.

In the original paper (loc. cit.) the weight and lengths of these bones, when room dried or oven dried, are also given. It will be sufficient here however to introduce a series of corrections to be applied for each change in state—table 132.

TABLE 128

*Absolute weight of fresh limb bones, on body weight. Values taken from smoothed graphs in chart 25.*

| BODY WEIGHT | HUMERUS (2) | ULNA PLUS RADIUS (2) | FEMUR (2) | TIBIA PLUS FIBULA (2) |
|---|---|---|---|---|
| *grams* | *grams* | *grams* | *grams* | *grams* |
| 5 | 0.03 | 0.02 | 0.03 | 0.03 |
| 10 | 0.05 | 0.03 | 0.05 | 0.05 |
| 15 | 0.07 | 0.05 | 0.10 | 0.10 |
| 20 | 0.09 | 0.07 | 0.14 | 0.12 |
| 25 | 0.11 | 0.08 | 0.16 | 0.14 |
| 30 | 0.12 | 0.09 | 0.19 | 0.17 |
| 35 | 0.13 | 0.09 | 0.22 | 0.19 |
| 40 | 0.14 | 0.10 | 0.25 | 0.21 |
| 45 | 0.15 | 0.11 | 0.29 | 0.24 |
| 50 | 0.17 | 0.12 | 0.31 | 0.26 |
| 55 | 0.18 | 0.13 | 0.34 | 0.28 |
| 60 | 0.19 | 0.13 | 0.37 | 0.30 |
| 65 | 0.20 | 0.14 | 0.40 | 0.33 |
| 70 | 0.22 | 0.14 | 0.43 | 0.35 |
| 75 | 0.23 | 0.15 | 0.45 | 0.38 |
| 80 | 0.24 | 0.16 | 0.48 | 0.39 |
| 85 | 0.25 | 0.16 | 0.50 | 0.41 |
| 90 | 0.26 | 0.17 | 0.53 | 0.43 |
| 95 | 0.27 | 0.18 | 0.55 | 0.45 |
| 100 | 0.28 | 0.19 | 0.57 | 0.47 |
| 110 | 0.30 | 0.20 | 0.62 | 0.52 |
| 120 | 0.33 | 0.21 | 0.67 | 0.55 |
| 130 | 0.35 | 0.23 | 0.72 | 0.58 |
| 140 | 0.37 | 0.24 | 0.78 | 0.61 |
| 150 | 0.39 | 0.26 | 0.83 | 0.63 |
| 160 | 0.41 | 0.27 | 0.87 | 0.66 |
| 170 | 0.43 | 0.28 | 0.92 | 0.69 |
| 180 | 0.45 | 0.30 | 0.96 | 0.72 |
| 190 | 0.47 | 0.31 | 1.00 | 0.75 |
| 200 | 0.49 | 0.33 | 1.04 | 0.77 |
| 210 | 0.50 | 0.34 | 1.08 | 0.80 |
| 220 | 0.52 | 0.35 | 1.13 | 0.83 |
| 230 | 0.54 | 0.37 | 1.17 | 0.86 |
| 240 | 0.56 | 0.38 | 1.22 | 0.89 |
| 250 | 0.58 | 0.39 | 1.26 | 0.92 |
| 270 | 0.61 | 0.42 | 1.35 | 0.98 |
| 290 | 0.65 | 0.45 | 1.43 | 1.03 |
| 310 | 0.69 | 0.48 | 1.52 | 1.08 |
| 330 | 0.72 | 0.50 | 1.60 | 1.14 |
| 350 | 0.75 | 0.52 | 1.68 | 1.20 |
| 370 | 0.78 | 0.54 | 1.75 | 1.25 |
| 390 | 0.81 | 0.56 | 1.82 | 1.30 |
| 410 | 0.84 | 0.57 | 1.88 | 1.36 |
| 430 | 0.87 | 0.59 | 1.95 | 1.41 |
| 450 | 0.91 | 0.61 | 2.02 | 1.47 |
| 470 | 0.94 | 0.62 | 2.09 | 1.53 |
| 485 | 0.96 | 0.64 | 2.14 | 1.57 |

### TABLE 129

*Absolute weight of room-dried limb bones, on body weight.* *No chart*

| BODY WEIGHT | HUMERUS (2) | ULNA PLUS RADIUS (2) | FEMUR (2) | TIBIA PLUS FIBULA (2) |
|---|---|---|---|---|
| *grams* | *grams* | *grams* | *grams* | *grams* |
| 5 | 0.007 | 0.005 | 0.007 | 0.008 |
| 10 | 0.013 | 0.010 | 0.012 | 0.014 |
| 15 | 0.021 | 0.018 | 0.028 | 0.033 |
| 20 | 0.030 | 0.028 | 0.044 | 0.043 |
| 25 | 0.040 | 0.035 | 0.053 | 0.054 |
| 30 | 0.047 | 0.041 | 0.067 | 0.070 |
| 35 | 0.052 | 0.045 | 0.082 | 0.082 |
| 40 | 0.060 | 0.052 | 0.098 | 0.095 |
| 45 | 0.067 | 0.060 | 0.120 | 0.113 |
| 50 | 0.079 | 0.067 | 0.134 | 0.127 |
| 55 | 0.088 | 0.076 | 0.153 | 0.142 |
| 60 | 0.095 | 0.079 | 0.172 | 0.159 |
| 65 | 0.102 | 0.088 | 0.192 | 0.178 |
| 70 | 0.115 | 0.092 | 0.211 | 0.193 |
| 75 | 0.124 | 0.101 | 0.229 | 0.214 |
| 80 | 0.133 | 0.110 | 0.250 | 0.225 |
| 85 | 0.141 | 0.112 | 0.268 | 0.240 |
| 90 | 0.150 | 0.122 | 0.291 | 0.258 |
| 95 | 0.160 | 0.131 | 0.310 | 0.276 |
| 100 | 0.170 | 0.140 | 0.329 | 0.295 |
| 110 | 0.188 | 0.153 | 0.370 | 0.337 |
| 120 | 0.213 | 0.164 | 0.410 | 0.368 |
| 130 | 0.233 | 0.182 | 0.452 | 0.399 |
| 140 | 0.251 | 0.193 | 0.502 | 0.427 |
| 150 | 0.267 | 0.211 | 0.540 | 0.446 |
| 160 | 0.281 | 0.221 | 0.572 | 0.473 |
| 170 | 0.297 | 0.230 | 0.613 | 0.500 |
| 180 | 0.312 | 0.247 | 0.643 | 0.528 |
| 190 | 0.328 | 0.257 | 0.674 | 0.553 |
| 200 | 0.344 | 0.274 | 0.703 | 0.568 |
| 210 | 0.353 | 0.284 | 0.733 | 0.591 |
| 220 | 0.369 | 0.294 | 0.768 | 0.614 |
| 230 | 0.384 | 0.311 | 0.799 | 0.638 |
| 240 | 0.400 | 0.321 | 0.834 | 0.662 |
| 250 | 0.416 | 0.330 | 0.861 | 0.686 |
| 270 | 0.439 | 0.357 | 0.927 | 0.733 |
| 290 | 0.469 | 0.383 | 0.987 | 0.774 |
| 310 | 0.501 | 0.411 | 1.052 | 0.815 |
| 330 | 0.523 | 0.431 | 1.112 | 0.864 |
| 350 | 0.547 | 0.449 | 1.170 | 0.912 |
| 370 | 0.571 | 0.469 | 1.224 | 0.952 |
| 390 | 0.595 | 0.489 | 1.280 | 0.997 |
| 410 | 0.620 | 0.499 | 1.325 | 1.047 |
| 430 | 0.644 | 0.519 | 1.380 | 1.090 |
| 450 | 0.675 | 0.540 | 1.433 | 1.138 |
| 470 | 0.700 | 0.552 | 1.490 | 1.190 |
| 485 | 0.717 | 0.571 | 1.528 | 1.227 |

TABLE 130

*Absolute length of fresh limb bones in millimeters, on body weight. Values taken from the smoothed graphs in chart 25 a*

| BODY WEIGHT | HUMERUS | ULNA | RADIUS | FEMUR | TIBIA |
|---|---|---|---|---|---|
| *grams* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| 5 | 7.0 | 8.0 | 6.4 | 7.4 | 7.0 |
| 10 | 10.2 | 11.8 | 9.0 | 11.0 | 12.0 |
| 15 | 12.0 | 14.0 | 11.1 | 12.9 | 15.6 |
| 20 | 12.9 | 15.5 | 12.0 | 14.4 | 17.9 |
| 25 | 13.7 | 16.5 | 12.6 | 15.7 | 19.3 |
| 30 | 14.3 | 17.4 | 13.2 | 16.8 | 20.7 |
| 35 | 14.8 | 18.2 | 13.7 | 17.9 | 21.7 |
| 40 | 15.4 | 18.8 | 14.2 | 18.7 | 22.4 |
| 45 | 15.8 | 19.2 | 14.6 | 19.5 | 23.3 |
| 50 | 16.5 | 19.6 | 15.0 | 20.1 | 24.0 |
| 55 | 16.8 | 19.9 | 15.5 | 20.9 | 24.9 |
| 60 | 17.5 | 20.3 | 16.0 | 21.5 | 25.5 |
| 65 | 17.8 | 20.9 | 16.3 | 22.0 | 26.2 |
| 70 | 18.3 | 21.2 | 16.7 | 22.7 | 26.8 |
| 75 | 18.7 | 21.7 | 17.2 | 23.2 | 27.5 |
| 80 | 19.0 | 22.0 | 17.6 | 23.9 | 28.0 |
| 85 | 19.4 | 22.6 | 18.0 | 24.4 | 28.5 |
| 90 | 19.8 | 22.9 | 18.4 | 24.8 | 29.0 |
| 95 | 20.1 | 23.2 | 18.6 | 25.4 | 29.6 |
| 100 | 20.5 | 23.7 | 18.9 | 25.8 | 29.8 |
| 110 | 21.2 | 24.5 | 19.5 | 26.8 | 30.7 |
| 120 | 21.7 | 25.2 | 20.2 | 27.7 | 31.6 |
| 130 | 22.4 | 25.9 | 20.8 | 28.7 | 32.2 |
| 140 | 22.9 | 26.6 | 21.3 | 29.5 | 32.8 |
| 150 | 23.6 | 27.1 | 21.8 | 30.2 | 33.4 |
| 160 | 24.0 | 27.7 | 22.2 | 31.0 | 33.9 |
| 170 | 24.6 | 28.3 | 22.7 | 31.6 | 34.5 |
| 180 | 25.0 | 28.8 | 23.1 | 32.2 | 34.9 |
| 190 | 25.4 | 29.3 | 23.4 | 32.8 | 35.5 |
| 200 | 25.8 | 29.8 | 23.8 | 33.4 | 36.0 |
| 210 | 26.1 | 30.2 | 24.1 | 34.0 | 36.5 |
| 220 | 26.5 | 30.6 | 24.3 | 34.6 | 37.0 |
| 230 | 26.9 | 30.9 | 24.6 | 35.0 | 37.3 |
| 240 | 27.1 | 31.2 | 24.8 | 35.5 | 37.7 |
| 250 | 27.5 | 31.5 | 25.0 | 36.0 | 38.1 |
| 270 | 28.3 | 32.0 | 25.5 | 36.8 | 38.8 |
| 290 | 28.9 | 32.3 | 26.0 | 37.4 | 39.5 |
| 310 | 29.4 | 32.8 | 26.3 | 38.0 | 40.0 |
| 330 | 29.8 | 33.2 | 26.7 | 38.7 | 40.5 |
| 350 | 30.0 | 33.6 | 27.0 | 39.2 | 41.0 |
| 370 | 30.3 | 34.0 | 27.2 | 39.7 | 41.5 |
| 390 | 30.7 | 34.4 | 27.5 | 39.9 | 41.9 |
| 410 | 31.0 | 34.9 | 27.8 | 40.2 | 42.4 |
| 430 | 31.0 | 35.2 | 28.0 | 40.4 | 43.0 |
| 450 | 31.2 | 35.6 | 28.3 | 40.7 | 43.3 |
| 470 | 31.3 | 36.0 | 28.5 | 41.0 | 43.8 |
| 485 | 31.3 | 36.2 | 28.6 | 41.2 | 44.1 |

## TABLE 131

*Absolute length of fresh limb bones in millimeters, on body length.*

| BODY LENGTH | HUMERUS | ULNA | RADIUS | FEMUR | TIBIA |
|---|---|---|---|---|---|
| *mm.* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| 47.5 | 7.0 | 7.5 | 6.2 | 6.4 | 7.0 |
| 50.0 | 7.1 | 7.7 | 6.5 | 6.8 | 7.3 |
| 52.5 | 7.3 | 7.8 | 6.7 | 7.2 | 7.6 |
| 55.0 | 7.6 | 8.1 | 6.8 | 7.6 | 8.0 |
| 57.5 | 8.0 | 8.6 | 7.1 | 7.9 | 8.5 |
| 60.0 | 8.6 | 9.3 | 7.4 | 8.3 | 9.0 |
| 62.5 | 9.4 | 10.0 | 8.0 | 8.9 | 9.7 |
| 65.0 | 10.1 | 10.7 | 8.6 | 9.6 | 10.9 |
| 67.5 | 10.5 | 11.4 | 9.2 | 10.2 | 11.9 |
| 70.0 | 10.9 | 12.3 | 9.8 | 10.6 | 12.8 |
| 72.5 | 11.1 | 12.9 | 10.3 | 11.1 | 13.7 |
| 75.0 | 11.3 | 13.3 | 10.6 | 11.5 | 14.4 |
| 77.5 | 11.6 | 13.6 | 10.9 | 11.9 | 15.2 |
| 80.0 | 11.9 | 14.0 | 11.1 | 12.4 | 15.8 |
| 82.5 | 12.2 | 14.4 | 11.4 | 12.8 | 16.3 |
| 85.0 | 12.4 | 14.8 | 11.6 | 13.2 | 16.8 |
| 87.5 | 12.7 | 15.2 | 11.8 | 13.6 | 17.3 |
| 90.0 | 13.0 | 15.6 | 12.1 | 14.0 | 17.8 |
| 92.5 | 13.3 | 16.0 | 12.3 | 14.5 | 18.3 |
| 95.0 | 13.6 | 16.4 | 12.4 | 14.9 | 18.7 |
| 100.0 | 14.1 | 17.2 | 12.9 | 15.7 | 19.5 |
| 105.0 | 14.7 | 17.8 | 13.4 | 16.6 | 20.3 |
| 110.0 | 15.1 | 18.3 | 13.8 | 17.3 | 21.1 |
| 115.0 | 15.6 | 18.8 | 14.3 | 18.2 | 21.8 |
| 120.0 | 15.9 | 19.1 | 14.7 | 19.0 | 22.7 |
| 125.0 | 16.3 | 19.5 | 15.1 | 19.8 | 23.6 |
| 130.0 | 16.8 | 19.9 | 15.4 | 20.7 | 24.5 |
| 135.0 | 17.2 | 20.4 | 15.8 | 21.5 | 25.3 |
| 140.0 | 17.9 | 20.9 | 16.3 | 22.2 | 26.3 |
| 145.0 | 18.4 | 21 6 | 16.9 | 23.2 | 27.1 |
| 150.0 | 19.0 | 22.1 | 17.5 | 24.2 | 27.9 |
| 155.0 | 19.9 | 23.0 | 18.2 | 25.1 | 28.8 |
| 160.0 | 20.6 | 23.9 | 18.8 | 26.1 | 29.7 |
| 165.0 | 21.2 | 24.8 | 19.5 | 27.0 | 30.5 |
| 170.0 | 22.0 | 25.3 | 20.1 | 28.0 | 31.4 |
| 175.0 | 22.8 | 26.1 | 20.8 | 29.0 | 32.2 |
| 180.0 | 23.3 | 26.9 | 21.4 | 29.9 | 33.1 |
| 185.0 | 24.0 | 27.8 | 22.0 | 30.8 | 33.9 |
| 190.0 | 24.9 | 28.6 | 22.8 | 31.8 | 34.7 |
| 195.0 | 25.8 | 29.5 | 23.6 | 32.8 | 35.6 |
| 200.0 | 26.3 | 30.3 | 24.2 | 33.7 | 36.4 |
| 210.0 | 27.6 | 31.5 | 25.4 | 35.6 | 38.0 |
| 220.0 | 28.9 | 32.8 | 26.3 | 37.5 | 39.6 |
| 230.0 | 30.2 | 34.0 | 27.3 | 39.2 | 41.2 |
| 240.0 | 31.3 | 35.0 | 28.2 | 40.5 | 42.6 |
| 250.0 | 32.2 | 36.1 | 29.1 | 41.8 | 44.2 |

The fact that these bones continue to increase in length nearly as long as the rat lives, implies a condition which makes possible this continued growth, as shown in table 131.

Table 132 gives the data by which determinations of length in any of the three states can be transformed.

TABLE 132

*Percentage losses in the length of long bones on drying. Mean values for rats above 100 grams in body weight*

| AMOUNT OF CHANGE | AVERAGE PERCENTAGE LOSS IN LENGTH ON DRYING | | | | |
|---|---|---|---|---|---|
| | Humerus | Ulna | Radius | Femur | Tibia |
| | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| Fresh to room dried: loss | 0.6 | 0.4 | 0.4 | 0.7 | 0.5 |
| Room dried to oven dried: loss | 0.3 | 0.2 | 0.2 | 0.3 | 0.2 |
| Fresh to oven dried: loss | 0.9 | 0.6 | 0.6 | 1.0 | 0.7 |

TABLE 133

*The mean weight in grams of the crania in each body weight group of the four series of albino rats from Paris, London, Philadelphia, Vienna (based on table 4, Donaldson '12 a). Each weight group is based on six cases, three males and three females.*

| BODY WEIGHT GROUP | WEIGHT OF CRANIA IN GRAMS | | | |
|---|---|---|---|---|
| | London | Paris | Philadelphia | Vienna |
| *grams* | | | | |
| 125 | 0.89 | 1.03 | 1.05 | 1.00 |
| 175 | 1.23 | 1.27 | 1.41 | 1.40 |
| 225 | 1.52 | 1.52 | 1.51 | 1.73 |
| 275 | 1.79 | | 1.87 | 2.10 |
| 325 | | | 2.15 | |

For the corresponding weights of the Norway crania see table 191.

(*c*) *Weight of cranium.* Determinations of the weight of the cranium dried at room temperature have been made, Donaldson ('12 a). By the cranium is meant the skull with upper teeth, minus the mandible with lower teeth and minus the ear bones. The mean weights are given in table 133. These crania were preserved originally in weak alcohol.

TABLE 134

*Absolute weight of cranium—fresh, room-dried, and oven-dried—on body weight. Values from the smoothed graphs in chart 26.*

| BODY WEIGHT | FRESH | ROOM-DRIED | OVEN-DRIED |
|---|---|---|---|
| *grams* | *grams* | *grams* | *grams* |
| 5 | 0.19 | 0.04 | 0.04 |
| 10 | 0.32 | 0.09 | 0.08 |
| 15 | 0.42 | 0.14 | 0.13 |
| 20 | 0.51 | 0.20 | 0.18 |
| 25 | 0.61 | 0.24 | 0.22 |
| 30 | 0.67 | 0.27 | 0.25 |
| 35 | 0.72 | 0.32 | 0.29 |
| 40 | 0.78 | 0.36 | 0.33 |
| 45 | 0.83 | 0.41 | 0.37 |
| 50 | 0.89 | 0.45 | 0.41 |
| 55 | 0.94 | 0.49 | 0.45 |
| 60 | 1.00 | 0.54 | 0.49 |
| 65 | 1.05 | 0.58 | 0.53 |
| 70 | 1.11 | 0.63 | 0.57 |
| 75 | 1.17 | 0.66 | 0.60 |
| 80 | 1.22 | 0.71 | 0.65 |
| 85 | 1.28 | 0.76 | 0.69 |
| 90 | 1.33 | 0.80 | 0.73 |
| 95 | 1.39 | 0.85 | 0.77 |
| 100 | 1.44 | 0.89 | 0.81 |
| 110 | 1.56 | 0.96 | 0.87 |
| 120 | 1.67 | 1.01 | 0.92 |
| 130 | 1.75 | 1.06 | 0.97 |
| 140 | 1.83 | 1.12 | 1.02 |
| 150 | 1.92 | 1.18 | 1.08 |
| 160 | 2.00 | 1.23 | 1.12 |
| 170 | 2.08 | 1.29 | 1.18 |
| 180 | 2.17 | 1.35 | 1.23 |
| 190 | 2.24 | 1.40 | 1.28 |
| 200 | 2.32 | 1.47 | 1.34 |
| 210 | 2.41 | 1.51 | 1.38 |
| 220 | 2.50 | 1.56 | 1.42 |
| 230 | 2.56 | 1.61 | 1.47 |
| 240 | 2.62 | 1.67 | 1.52 |
| 250 | 2.69 | 1.72 | 1.57 |
| 270 | 2.82 | 1.83 | 1.67 |
| 290 | 2.96 | 1.93 | 1.76 |
| 310 | 3.09 | 2.02 | 1.84 |
| 330 | 3.22 | 2.11 | 1.92 |
| 350 | 3.34 | 2.20 | 2.01 |
| 370 | 3.44 | 2.29 | 2.09 |
| 390 | 3.55 | 2.38 | 2.17 |
| 410 | 3.66 | 2.47 | 2.25 |
| 430 | 3.77 | 2.57 | 2.34 |
| 450 | 3.88 | 2.65 | 2.42 |
| 470 | 3.97 | 2.72 | 2.48 |
| 485 | 4.01 | 2.74 | 2.50 |

The weight of the cranium at 42 body weights has also been determined by Donaldson and Conrow ('19) and the results are given in table 134 and Chart 26.

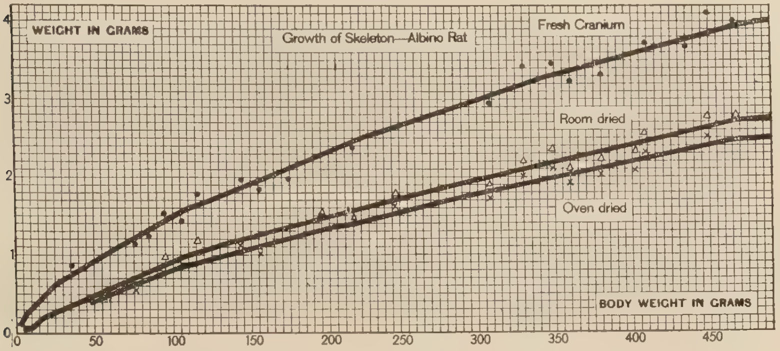

Chart 26 Absolute weight of the cranium—fresh, room-dried and oven-dried —on body weight (albino rat). Table 134.
● Fresh. Δ Room dried. × Oven dried.

TABLE 135

*Absolute and relative weight of the fresh mandibles. The relative weights are based on the weight of the cranium, taken from table 134*

| BODY WEIGHT | CRANIUM WEIGHT | MANDIBLES WEIGHT | PER CENT WEIGHT OF MANDIBLES ON CRANIUM |
|---|---|---|---|
| *grams* | *grams* | *grams* | |
| 5 | 0.19 | 0.033 | 17.37 |
| 10 | 0.32 | 0.075 | 23.44 |
| 15 | 0.42 | 0.110 | 26.19 |
| 20 | 0.51 | 0.140 | 27.45 |
| 25 | 0.61 | 0.168 | 27.54 |
| 30 | 0.67 | 0.193 | 28.81 |
| 35 | 0.72 | 0.218 | 30.28 |
| 40 | 0.78 | 0.238 | 30.51 |
| 45 | 0.83 | 0.258 | 31.08 |
| 50 | 0.89 | 0.278 | 31.24 |
| 75 | 1.17 | 0.378 | 32.31 |
| 100 | 1.44 | 0.470 | 32.64 |
| 150 | 1.92 | 0.643 | 33.49 |
| 200 | 2.32 | 0.790 | 34.05 |
| 250 | 2.69 | 0.908 | 33.75 |
| 300 | 3.02 | 1.002 | 33.17 |
| 350 | 3.34 | 1.083 | 32.43 |
| 400 | 3.60 | 1.161 | 32.25 |
| 450 | 3.88 | 1.240 | 31.96 |

As it is sometimes important to recover the weight of the cranium when it has been destroyed by dissection, table 135 is introduced giving the weight of the two mandibles with teeth, both absolute and as a percentage of the cranium. Thus by getting the weight of the fresh mandibles in any case it is possible by the aid of table 135 to compute approximately the weight of the cranium. After 100 grams this percentage relation varies but slightly, though it tends to increase up to a body weight of 200 grams, after which it slowly diminishes.

TABLE 136

*Showing growth changes in the blood in rats of increasing age (body weight). Sexes combined—based on tables I and II, Chisolm ('11)*

| NUMBER OF ANIMALS | AGE | BODY WEIGHT (ROUNDED) | LENGTH OF BODY | HB | $O_2$ CAPACITY |  | BLOOD VOLUME |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | Total | Per kilo body weight | Total | Per kilo body weight |
|  | *days* | *grams* | *mm.* | *per cent* | *cc.* | *cc.* | *cc.* | *cc.* |
| 2 | 1 | 4 |  | 89.0 | 0.0411 | 11.59 | 0.249 | 70.3 |
| 5 | 2 | 5 | 47 | 72.0 | 0.0466 | 9.79 | 0.350 | 73.5 |
| 3 | 8 | 10 | 59 | 50.3 | 0.0485 | 4.83 | 0.522 | 52.0 |
| 9 | 16 | 13 | 72 | 63.0 | 0.0639 | 4.99 | 0.544 | 42.5 |
| 3 | 21 | 14 | 82 | 49.0 | 0.0773 | 5.44 | 0.863 | 60.4 |
| 3 | 28 | 14 | 84 | 44.7 | 0.0891 | 6.17 | 1.070 | 74.4 |
| 9 |  | 37 | 112 | 76.0 | 0.3730 | 10.00 | 2.620 | 70.0 |
| 8 |  | 57 | 134 | 84.6 | 0.5630 | 9.92 | 3.610 | 63.7 |
| 8 |  | 66 | 140 | 85.1 | 0.6490 | 9.88 | 4.120 | 62.7 |
| 12 |  | 75 | 144 | 79.9 | 0.7220 | 9.60 | 4.940 | 65.7 |
| 15 |  | 86 | 148 | 82.4 | 0.8600 | 10.02 | 5.670 | 66.0 |
| 8 |  | 95 | 155 | 84.0 | 0.9550 | 10.02 | 6.070 | 63.9 |
| 8 |  | 106 | 159 | 82.4 | 1.0270 | 9.74 | 6.810 | 64.5 |
| 11 |  | 115 | 166 | 92.5 | 1.2130 | 10.51 | 6.970 | 60.5 |
| 9 |  | 125 | 169 | 92.6 | 1.2410 | 9.89 | 7.260 | 57.9 |
| 8 |  | 146 | 178 | 89.1 | 1.4460 | 9.92 | 8.870 | 60.8 |
| 8 |  | 165 | 180 | 92.0 | 1.6630 | 10.10 | 9.890 | 59.3 |
| 7 |  | 194 | 189 | 92.4 | 1.9880 | 10.28 | 11.820 | 61.0 |
| 10 |  | 227 | 201 | 89.9 | 2.1860 | 9.68 | 13.180 | 58.2 |
| 8 |  | 268 | 206 | 85.4 | 2.2300 | 8.36 | 14.150 | 53.0 |

3. *Teeth.* For the data on the growth of the incisor teeth (Addison and Appleton, '15), see chapter 3, pp. 53 and 54.

4. *Blood.* By means of a formula (21) based on his observations, Chisolm ('11) was able to compute the volume of the blood in rats of different body weights (Table 136). Hatai (MS '14) has added two formulas (21a) (21b) based on that of

Chisolm and giving results somewhat closer to the observations when the determinations are made according to sex.

These three formulas have been transformed in turn from volume to weight by using as a factor 1.056—the specific gravity of the blood—and three formulas for blood weight (22) (22 a) (22 b) have been thus obtained. These last have been used to compute the weight of the blood as given in table 146. Table 136 here given presents Chisolm's data on the other growth changes in the blood.

Abderhalden ('02) found that the percentage of haemoglobin is higher in the smaller—younger—rats than in the larger—older—ones.

TABLE 137

*Showing the weight of haemoglobin per kilo of body weight. Three to five rats in each group*

| NUMBER OF GROUPS | CORRECTED* BODY WEIGHT | HAEMOGLOBIN PER KILO |
|---|---|---|
| | *grams* | *grams* |
| 7 | 166 | 9.56 |
| 10 | 121 | 9.57 |
| 15 | 68 | 9.77 |
| 10 | 37 | 10.36 |

* The corrected body weights are without skin and intestines. These values are therefore about 75 per cent of the gross body weight values.

The results are of the same order as those for the weight of blood but have not been corrected for the change in the percentage of water, table 137.

5. *Fat.* Boycott and Damant ('08, '08 a) have recorded the proportion of fat in rats of both sexes and of increasing body weights.

The total fat was determined in healthy animals living under ordinary laboratory conditions as to food. No details given. The fat was estimated by Leathes' modification of Liebermann's methods which is easily applicable to the entire carcasses of animals. The figures, given as percentages of fatty acid on the crude weight of the animal, represent therefore masked as well as anatomical fat.

From table 138 based on body weight, it appears that the proportion of fat tends to be greater in the heavier animals, and from the tables based on the data grouped according to sex, it appears that the females have a somewhat larger percentage of fat than do the males. The values for the fatty acids can be transformed into those for fat by multiplying by 1.046.

The proportion of fat (boiling alcohol extract) has been determined also by Hatai ('17) in a series ranging from birth to maturity (see table 166).

TABLE 138

*Giving the proportion of fat (fatty acids) with increasing age (body weight). Based on table A, Boycott and Damant ('08 a)*

| NUMBER AND SEX | | BODY WEIGHT | PERCENTAGE OF FATTY ACIDS | | |
|---|---|---|---|---|---|
| M. | F. | | Maximum | Minimum | Average |
| | | *grams* | | | |
| 15 | 10 | 20–49 | 9.2 | 0.85 | 4.1 |
| 8 | 7 | 50–99 | 6.1 | 1.00 | 4.0 |
| 19 | 25 | 100–149 | 16.1 | 0.80 | 6.1 |
| 11 | 17 | 150–199 | 14.6 | 1.30 | 7.6 |
| 7 | 2 | 200–247 | 9.7 | 1.30 | 5.8 |
| *Eighty-three rats arranged according to sex* | | | | | |
| Males 41 | | | 11.3 | 0.8 | 4.4 |
| Females 42 | | | 16.1 | 1.0 | 5.6 |

## GROWTH OF PARTS AND SYSTEMS OF THE BODY IN WEIGHT: REFERENCES

*Larger divisions.* Barry, '20. Jackson and Lowrey, '12. Jackson, '15 b.

*Systems.* Donaldson, '11, '11 c. Donaldson and Hatai, '11, '11 a. Donaldson, '12, '12 a. Jackson and Lowrey, '12. Osterud, '21.

*Ligamentous skeleton.* Donaldson and Conrow, '19. Jackson, '21.

*Cartilaginous skeleton.* Donaldson and Conrow, '19.

*Weight of cranium.* Donaldson, '12 a. Donaldson and Conrow, '19.

*Teeth.* Addison and Appleton, '15. Hammett and Justice ,'23. MacGillavry, 1875. Meyerheim, 1898.

*Blood.* Abderhalden, '02. Chisolm, '11.

*Fat.* Boycott and Damant, '08, '08 a. Hatai, '17.

# CHAPTER 7

## GROWTH OF PARTS AND ORGANS IN RELATION TO BODY LENGTH AND IN RELATION TO AGE

1. Introduction. 2. Measurements—Methods of Examination—Graphs 3. Body length on body weight: Body weight on body length: Tail length on body length (a) Body weight per millimeter of length. 4. Organs with early rapid growth. 5. Organs with a nearly uniform growth. 6. Organs with a sinuous graph of growth. 7. Variability. 8. General tables: Entire body on age: Prenatal—Postnatal: Increase in length and weight of parts and organs on body length. 9. Weight of thymus on age. 10. Weights of viscera. 11. Values for other characters linked with age. 12. Formulas.

1. *Introduction.* The organs, the growth of which has been followed are tail (length), brain, spinal cord, eyeballs, heart, kidneys, liver, spleen, lungs, blood, alimentary tract, testes, ovaries, hypophysis, suprarenals, thyroid and thymus.

The foregoing were presented in the first edition of this book. In the present edition there have been added from the Institute laboratory full tables on the epididymis, pancreas, stomach and submaxillary glands, together with crude data on the lens, pineal and prostate gland, and from other laboratories we have determinations (Osterud, MS.) of the growth of the parts of the female reproductive tracts. In addition, there are given tables on the growth in weight of the parts of the brain (Sugita, '17). The growth of the skeleton and its parts (Donaldson and Conrow, '19) has been considered on pages 183–198.

All the observations were made on stock Albinos from the colony at The Wistar Institute, except those for the total blood, which are based on the records of Chisolm, '11, and those for the parts of the female reproductive tract (Osterud, MS.).

The mean values for the several organs were in each instance charted and with these as a guide a theoretical graph was found which could be expressed by a formula or a series of formulas. All the formulas were devised by Dr. Hatai.

To present the results in a convenient form the organs have been grouped in the text according to the manner of their growth, and in most cases the description is accompanied by a chart showing the original data and the graph based on these data.

In each case reference is made to the formula or formulas on which the graph is based, but as a matter of convenience, the formulas utilized for the graphs are grouped in the section entitled "Formulas," pp. 282–298.

The charts serve to show the form of the graph of growth in each instance, but the precise weight values of the organs are to be read from the tables. For those who desire to find the weight of an organ in a rat of any body length or body weight a series of values—computed by the aid of the appropriate formulas—are given in tables 144–150 inclusive and in 152 and 153.

In making these tables the determinations for the corresponding body weights for each millimeter of length in each sex were first made by formulas (5a) and (5b) and the body weights so obtained were then used in computing the weights of the several organs.

In table 151 for the thymus however, it was found necessary to enter the weight values of the organ according to the age of the rat.

In table 152 the computed weight of the thymus on body weight is given on the assumption that the *body weights are normal to age* in conformity with the data in table 157.

2. *Measurements.—Methods of examination and graphs.* Unless otherwise stated the following determinations were made on stock Albinos taken from the colony at The Wistar Institute. The animals were killed with chloroform twenty hours after the last feeding and were dissected according to a fixed procedure.

3. *Body length on body weight.* Technic: Immediately after killing the rat was laid on its back and gently extended—the tail being drawn out straight. With jointed calipers the distance from the tip of the nose to the tip of the tail was taken and its values in millimeters found by applying the points to a scale. Next the distance from the tip of the nose to the center of the anus was found and its value in millimeters determined in the

same way. These measurements give first the total length, second, the body length and by the difference, the tail length.

Chart 27 gives the body length on the body weight. The data used are given in table 144. The values were computed by formula (4) and then corrected for each sex. The graphs show that for a given body weight the male has the greater body length. Donaldson '09; Donaldson and Hatai '11.

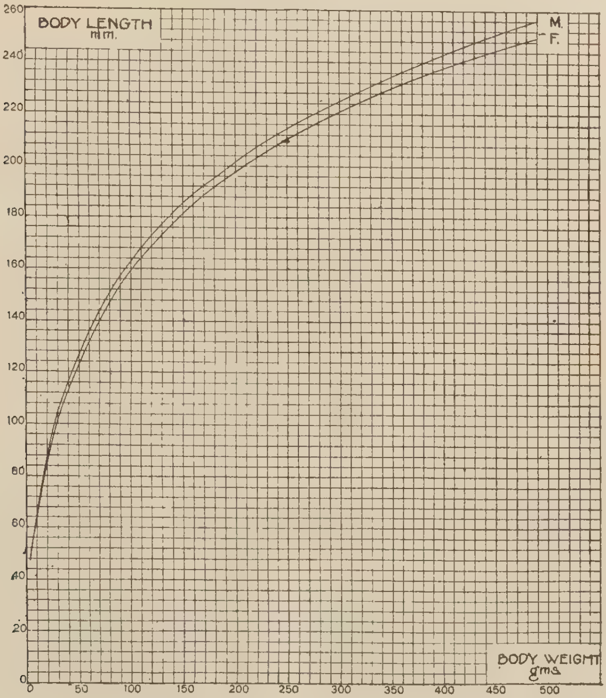

Chart 27 Giving for the males and females respectively the body length on the body weight. Formula (4): table 144.

*Body weight on body length.* The entire rat was next weighed to one-tenth of a gram. The weight thus obtained was *not* corrected for the contents of the alimentary canal—which according to Jackson and Lowrey ('12) amounts to about 5 per cent of the "gross" body weight. The uncorrected value is the gross body weight and the corrected, the "net" body weight of the

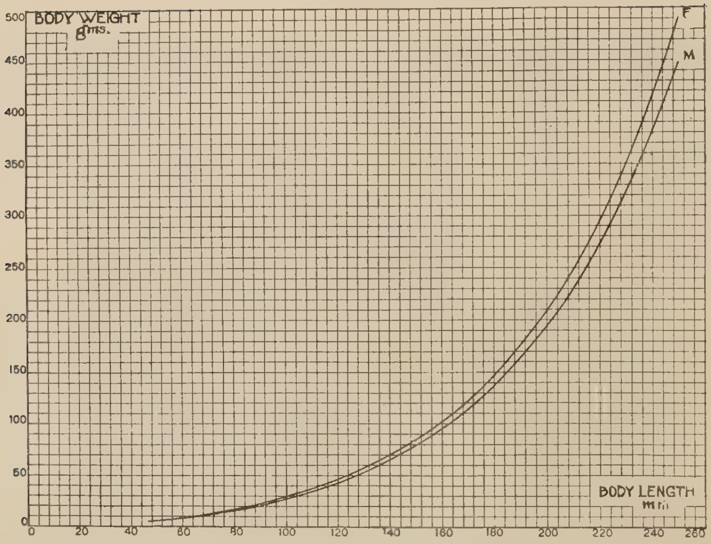

Chart 28 Giving for the males and females respectively the body weight on the body length. Formulas (5 a) and (5 b), table 144.

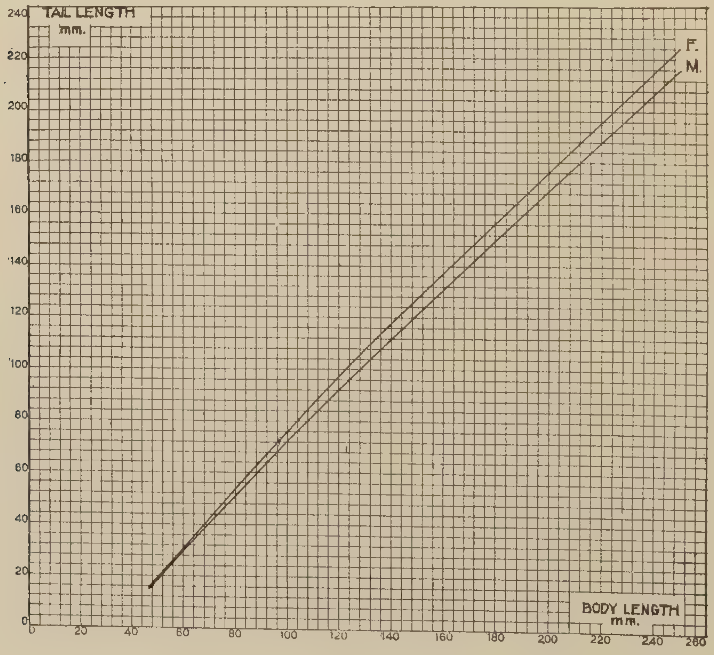

Chart 29 Giving the length of tail in millimeters on the body length, males, females. Formulas (7) and (8), table 144.

authors. In gravid females a correction was made however by subtracting the weight of the uterus and fetuses from the observed value. The weight of the body on the body length is given in chart 28.

The body weight values for each millimeter of body length in each sex are given in table 144. The graphs were computed by formulas (5a) and (5b), and show that for a given body length the female has a greater body weight. Donaldson '09, Donaldson and Hatai, '11.

*Tail length on body length.* The method of obtaining the tail length has been given under body length. The values for the graphs in chart 29 and for table 144 were determined by formulas (7) and (8). The tail is generally shorter than the body but in the female is relatively longer than in the male. It seems probable that six or seven of the caudal vertebrae are not formed till after birth.

TABLE 139

*Ratio of body length (B) divided by tail length (T) in rats reared at different temperatures (Przibram, '23)*

| EXTERNAL TEMPERATURE | RATIO B/T |
|---|---|
| 35° | 1.55 |
| 30° | 1.57 |
| 25° | 1.65 |
| 20° | 1.67 |
| 15° | 1.68 |
| 10° | 1.73 |

The relative length of the tail is modified by external temperature which in turn modifies the internal temperature. Low temperatures decrease the growth of the tail while high temperatures increase it. Thus the ratio of the body length divided by the tail length is modified as in table 139 (Przibram, '22 A-D).

It is possible also that the greater relative length of the tail in the female may be related to the higher body temperature in the female (Przibram, '22 B).

(*a*) *Body weight per millimeter of body length.* The relation between body weight and body length is shown by dividing the weight by the length and thus getting the weight per running millimeter—table 122.

These determinations show that after the middle of the suckling period, at about nine days of age, the values for the female exceed those for the male, and this excess tends to increase as the body length increases.

4. *Organs with an early rapid growth. Brain weight on body weight.* Technic: The rat was first eviscerated—this leaves in the brain a minimal amount of blood. The bones of the skull were removed from above. Care was taken to preserve the paraflocculi which lie in bony pockets.

The brain was severed from the cord by a section at the level of the first cervical nerve—coinciding as a rule with the tip of the calamus as seen from the dorsal aspect. The brain was then raised from the floor of the cranium—the nerves being clipped close to the base. The hypophysis was not included. Care was taken to obtain the olfactory bulbs entire. Thus prepared the brain was dropped into a small glass stoppered weighing bottle in which it was weighed to the tenth of a milligram. In this instance, as in the case of all of the other organs, the dissection was made under a glass hood to protect the operator from all drafts which might dry the organ during its preparation. The values for the graph, males only, chart 30 and for table 144 were computed by formulas (9) and (10) corrected for sex.

The graph for the male alone is given. As will be seen from table 144, for the same body length the female has a slightly lighter brain and this deficiency increases to about 1.5 per cent when the female is of the same body weight.

*Spinal cord weight on body weight.* Spinal cord—Technic: Following the removal of the brain (vide ante) the spinal cord was exposed by removing the arches of the vertebrae from neck to sacrum. The filum terminale was found and the cord raised—so that the roots of the spinal nerves could be clipped close to the cord. The mass thus removed with meninges—was placed in a glass stoppered weighing bottle and weighed to the tenth of a milligram. The values for the graph, males only, in chart 30 and for table 144 were computed by formula (13), corrected for sex. Donaldson ('08), ('09); Hatai, ('09 a).

For convenience the graph for the spinal cord is given on the same chart as that for the brain. The graph for the male only is entered. For the same body length as the male the spinal cord in the female is about 5 per cent heavier, and for the same body weight, about 2 per cent heavier. Donaldson ('08, '09); Hatai ('09 a).

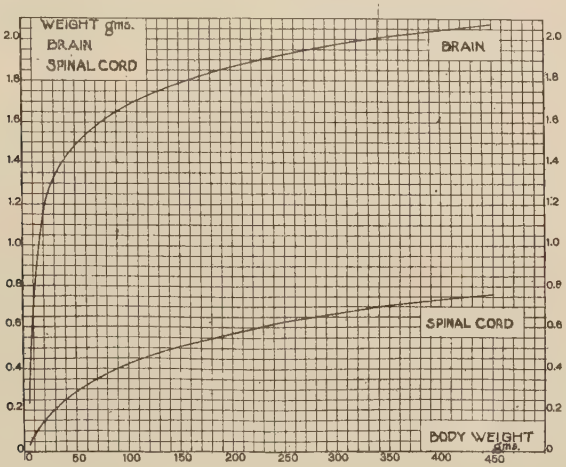

Chart 30 Giving the brain weight on the body weight. Males only. Formulas (9) and (10), table 144. Also spinal cord weight on the body weight. Males only. Formula (13), table 144.

*Weight of parts of the brain.* The change in the weight of the parts of the brain has been reported by Sugita ('17) table 140.

Technic: The olfactory bulbs were severed by a slightly oblique cut just caudad to the gray cap. The cerebellum was separated by section of the peduncles close to the stem. The stem was divided from the cerebrum by a section cephalad to the anterior quadrigemina.

*Weight of both eyeballs on body weight.* Technic: Care being taken to remove the muscle attachments, both eyes were weighed in a closed weighing bottle. The graph is based on rats studied by Jackson ('13). His results have been corroborated by studies on the stock Albinos from the colony of the Wistar Institute, Hatai ('13). The values for the graph in chart 31 and those given in table 144 are based on formula (15). The graph for the male only is entered, but the values for the female are like those for the male of the same body weight. Under unfavorable nutritional conditions the weight of the eyeballs follows the age rather than the body weight. Hatai (MS '14).

TABLE 140

*Giving for ten ages the total brain weights and their ratios, the weights of the parts and the ratios of the weights of parts to their respective initial weights at birth, in the albino rat brain*

| NUMBER OF CASES | AGE | TOTAL BRAIN WEIGHT | | CEREBRUM | | CEREBELLUM | | STEM | | OLFACTORY BULBS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Observed | Ratio | Observed | Ratio | Observed | Ratio | Observed | Ratio | Observed | Ratio |
| | *days* | *grams* | | *grams* | | *grams* | | *grams* | | *grams* | |
| | B | 0.236 | 1.0 | 0.150 | 1.0 | 0.008 | 1.0 | 0.073 | 1.0 | 0.005 | 1.0 |
| 4 | 4 | 0.482 | 2.0 | 0.338 | 2.3 | 0.023 | 2.9 | 0.105 | 1.4 | 0.016 | 3.2 |
| 3 | 5 | 0.503 | 2.1 | 0.349 | 2.3 | 0.026 | 3.3 | 0.113 | 1.5 | 0.015 | 2.0 |
| 2 | 20 | 1.153 | 4.9 | 0.817 | 5.4 | 0.126 | 15.8 | 0.171 | 2.3 | 0.039 | 7.8 |
| 3 | 35 | 1.355 | 5.7 | 0.870 | 5.8 | 0.197 | 23.4 | 0.248 | 3.4 | 0.040 | 8.0 |
| 4 | 50 | 1.469 | 6.2 | 0.974 | 6.5 | 0.197 | 23.4 | 0.258 | 3.5 | 0.040 | 8.0 |
| 3 | 60 | 1.531 | 6.5 | 0.959 | 6.4 | 0.226 | 28.3 | 0.278 | 3.8 | 0.068 | 13.6 |
| 2 | 70 | 1.612 | 6.8 | 1.033 | 6.9 | 0.215 | 26.9 | 0.331 | 4.5 | 0.033 | 6.6* |
| 5 | 90 | 1.779 | 7.5 | 1.121 | 7.5 | 0.244 | 30.5 | 0.337 | 4.6 | 0.077 | 15.4 |
| 4 | 150 | 1.933 | 8.2 | 1.191 | 8.0 | 0.275 | 34.4 | 0.373 | 5.1 | 0.094 | 18.8 |

* The olfactory bulbs are very variable in weight. Undeveloped bulbs like the above sometimes occur.

5. *Organs with a nearly uniform growth after the first very early phase of rapid growth—heart, kidneys, liver, spleen, lungs, (blood), alimentary tract, stomach, pancreas, submaxillaries, thyroid, hypophysis and suprarenals.*

In case of all of the organs to be described the preparation was carried on beneath a glass hood to prevent drying. The organ was weighed in a small glass stoppered bottle and the weight was taken to a tenth of a milligram.

*The weight of the heart on body weight.* Technic: The heart was removed after cutting all its vessels close to their proximal ends.

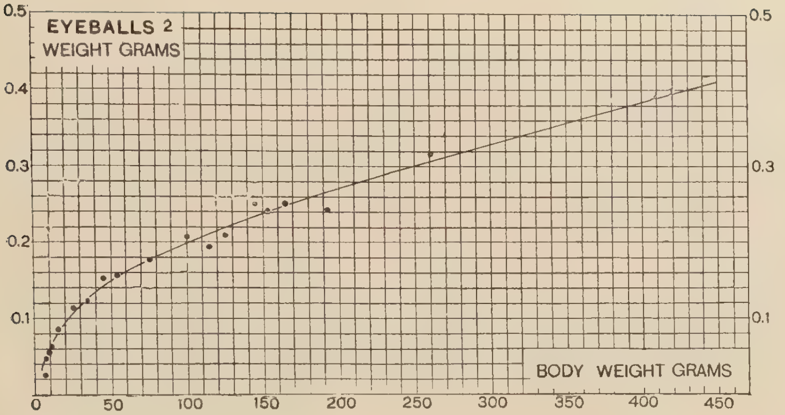

Chart 31 Showing the weight of eyeballs of the male albino rat according to body weight. The observed weights are represented by 149 male rats (Jackson). Table 144, formula (15).

• Observed weight. —— Calculated weight.

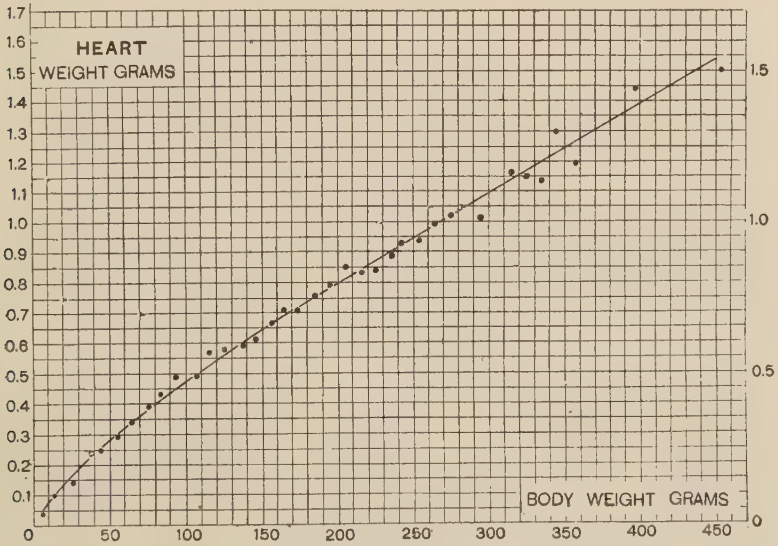

Chart 32 Showing the heart weight of the male albino rat according to body weight. The observed weights are represented by 134 male rats. Table 145 formula (16).

• Observed weight. —— Calculated weight.

It was then opened by longitudinal slits through its walls and the clots removed from the cavities thus exposed.

The graph given in chart 32 and the values in table 145 have been determined by formula (16).

The weight of the heart is closely correlated with that of the body and no difference according to sex has been noted. Hatai ('13); Jackson ('13).

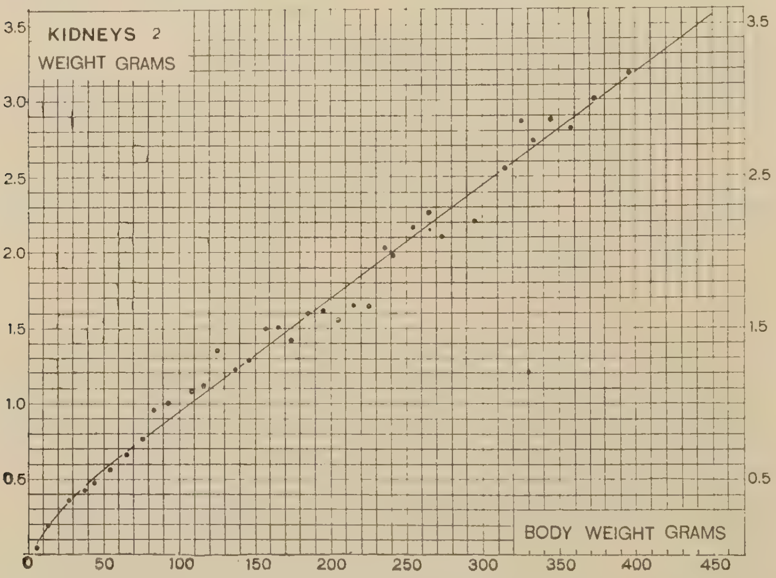

Chart 33 Showing the weight of kidneys of the male albino rat according to body weight. The observed weights are represented by 136 male rats. Table 145, formula (17).

• Observed weight. —— Calculated weight.

*Weight of both kidneys on body weight.* Technic: All vessels were cut close to the hilum and any superficial fat removed.

The graph given in chart 33 and the values in table 145 were determined by formula (17).

No sex difference was observed but the graph represents the determinations for the male only. Hatai ('13); Jackson ('13).

*Weight of the liver on the body weight.* Technic: The vessels were cut close to their entrance into the liver and the blood in the larger vessels gently pressed out. The graph given in chart 34 and the values in table 145 were determined by formula (18).

No sex difference in the weight of the liver has been noted—but the graph is given for the males only. Considerable variability is to be expected in the weight of an organ with such complex functions as those of the liver and this appears. A heavy liver usually accompanies a heavy spleen (Hatai). Hatai ('13); Jackson ('13).

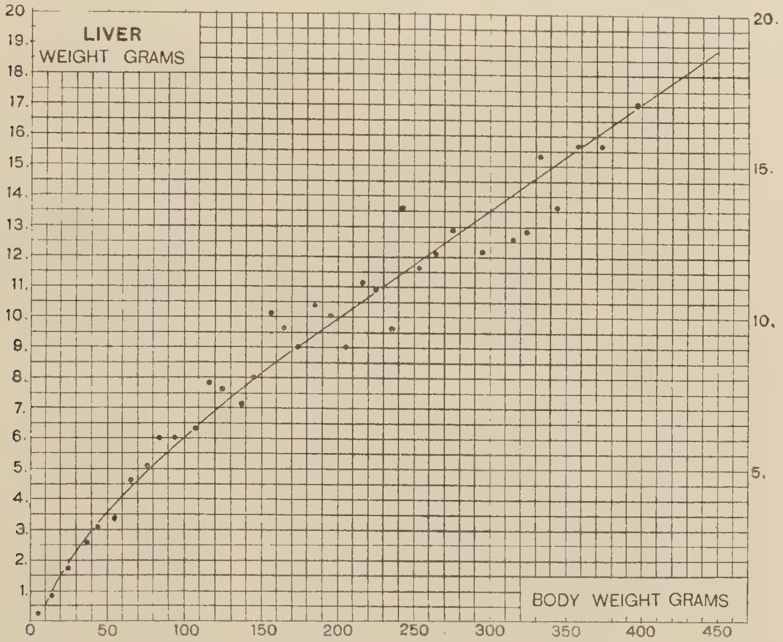

Chart 34 Showing the weight of liver of the male albino rat according to body weight. The observed weights are represented by 136 male rats. Table 145, formula (18).

• Observed weight. —— Calculated weight.

The liver should be removed as soon as possible after killing as it tends to gain weight by the absorption of blood. Further, the animal should have had no food for the previous 12–20 hours hours as the liver tends to enlarge during digestion (Rous and McMaster, '24).

*The weight of the spleen on the body weight.* Technic: The vessels were cut close to the hilum. The determination of the weight of the spleen is complicated by the occurrence of "enlarged spleens"—so called. These differ from the normal by being often several times the normal weight, darker in color, soft to the touch and showing on the surface dark or grayish patches. Spleens with these characters plainly marked were not used. The graph in chart 35 and the values in table 145 were determined by formula (19). No sex difference was observed but the graph is based on male records only. Hatai ('13); Jackson ('13).

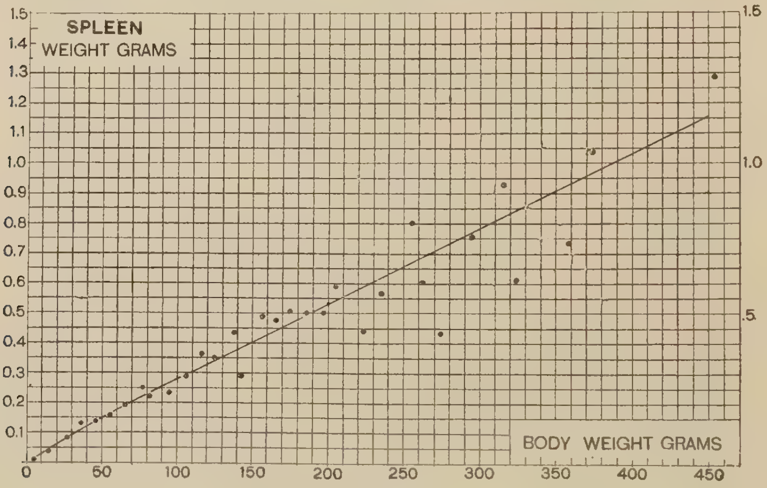

Chart 35 Showing the weight of spleen of the male albino rat according to body weight. The observed weights are represented by 87 male rats. Table 145, formula (19).

• Observed weight. —— Calculated weight.

*The weight of both lungs on the body weight.* Technic: The lungs are severed from the trachea and the portion of the esophagus usually taken out with them is removed. After the first three months of life the lungs of the rat are often infected. Such infected lungs may be highly altered—but are always abnormally heavy. The endeavor has been made to exclude infected lungs from the series—but doubtless some have been used. The graph in chart 36 and the values in table 146 were determined by formula (20). No sex difference has been noted but the graph is based on male data alone. Hatai ('13); Jackson ('13).

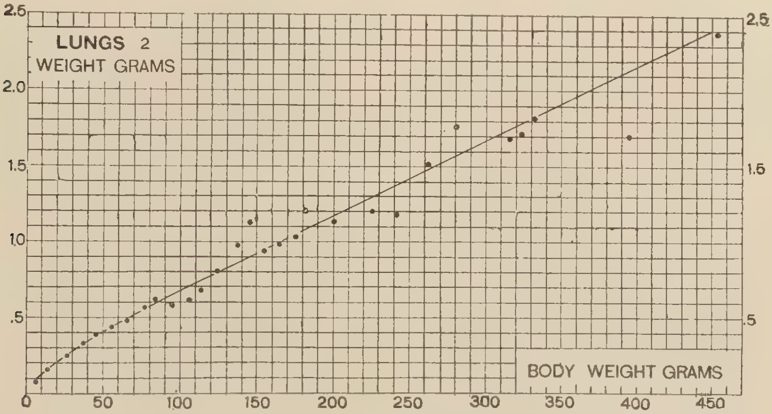

Chart 36 Showing the weight of lungs of the male albino rat according to body weight. The observed weights are represented by 90 male rats. Table 146, formula (20). • Observed weight. —— Calculated weight.

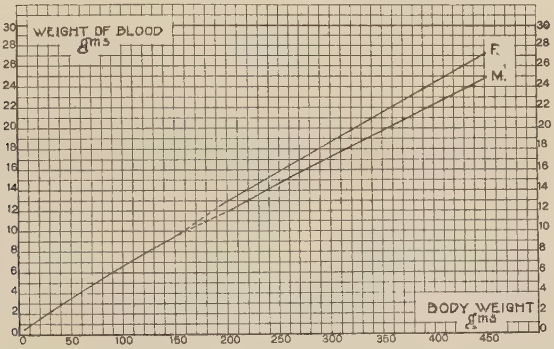

Chart 37 Giving weight of total blood on body weight. Males, females. Formulas (22), (22 a), and (22 b), table 146.

*Weight of the total blood on body weight.* Technic: The observations on this relation were made by Chisolm '11 on Albinos and pied rats. His methods are given in the paper cited above (pp. 207–208) and depend on determinations of the oxygen capacity. Chisolm's formulas have been revised by Hatai

(MS '14). The graph in chart 37 and the values in table 146 have been determined by formulas (22), (22 a), and (22 b). The data are for both sexes. Chisolm ('13); Jolly and Stini ('05).

*The weight of the alimentary tract on body weight.* Technic: The digestive tube from the level of the diaphragm to the anus was removed in its entirety—the pancreas, mesentery and small masses of fat being left adherent. The stomach and the large intestine were cut open and the contents removed while gentle pressure on the small intestine—exerted from above downwards—served to expel what it contained. The records are based on one series examined by Jackson ('13) and another series from The Wistar Institute colony. All are males. The graph in chart 38 and the values in table 146 were determined by formula (23). Sexes combined. Hatai ('13); and Jackson ('13).

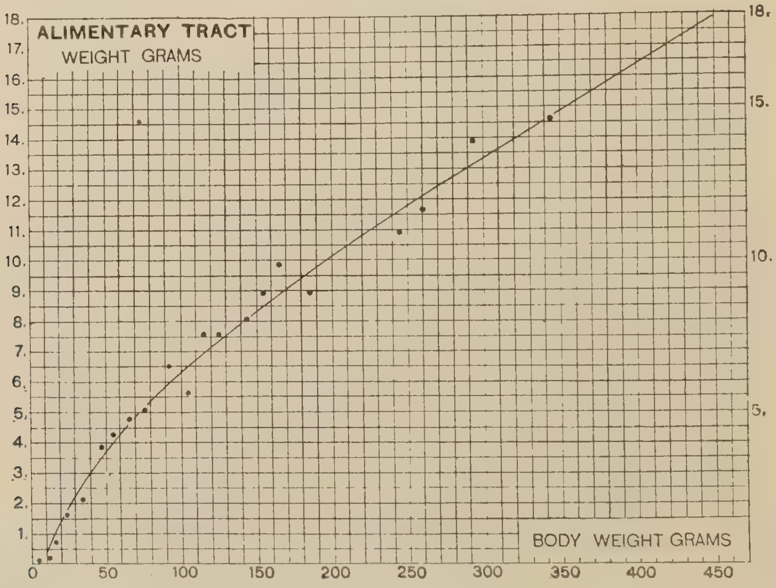

Chart 38 Showing the weight of alimentary tract of the male albino rat according to body weight. The observed weights are represented by 112 (Jackson) rats below 50 grams in body weight, and 82 (Wistar) rats above 50 grams in body weight. Table 146, formula (23).

• Observed weight. —— Calculated weight.

*The weight of the stomach on body weight—Hatai ('18).* Technic: The stomach is separated at the pyloric end where a deep constriction is clearly shown. The esophagus is cut close to the stomach—within a few millimeters. As soon as the stomach is removed, it is cut along the entire length and the contents are carefully removed by means of either the dull side of a knife or forceps. This can be easily done without injuring the stomach for the purpose of recording its weight.

The graph in chart 39 and the values in table 147 were determined by formulas (24) and (24a). On account of the peculiarity of the growth before weaning two formulas were necessary.

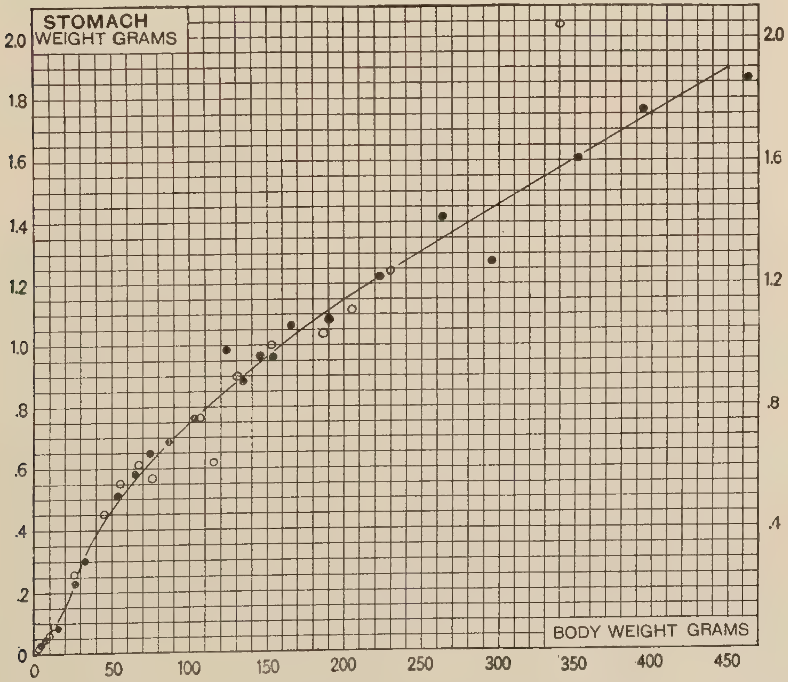

Chart 39 Showing the weight of the stomach of the albino rat according to body weight. The observed weights are represented by 152 male rats and 107 female rats, entered according to the groups given in table 147, formulas (24) and (24 a). • Observed weight, male. °Observed weight, female.
—— Calculated weight.

*The weight of the pancreas on body weight—Hatai, '18.* Technic: The pancreas is rather difficult to isolate from the surrounding structures such as omentum, lymphatic nodules, fat, etc. It is advisable to work first on young rats of about twenty-five days of age. In this state immediately after death the pancreas can be easily distinguished from the surrounding structures by its characteristic pinkish gray color. My own method is to cut the pancreas together with omentum from the line of attachment along the stomach and intestine. The adipose tissue can then be easily torn off by gentle pulling from the more solid pancreatic tissue. The omentum and lymphatic nodules may be removed by means of sharp scissors. In the adult rat the pancreas looks gray or grayish pink immediately after death. Some practice with younger rats is advisable before removing the pancreas from the older animals.

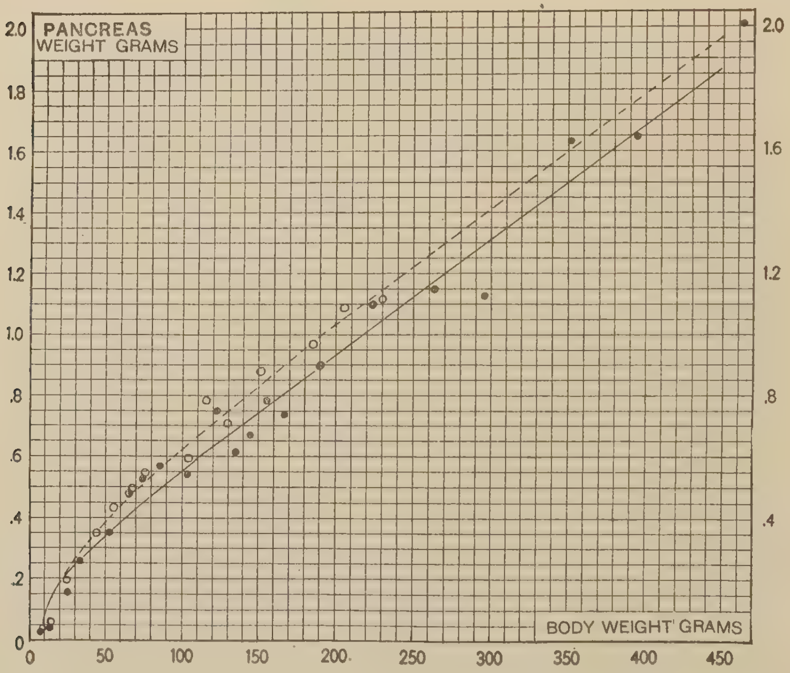

Chart 40 Showing the weight of the pancreas of the albino rat according to body weight. The observed weights are represented by 152 male rats and 107 female rats entered according to the groups given in table 147 and formulas (25) and (25 a).

- ● Observed weight, male.
- —— Calculated weight, male.
- ○ Observed weight, female.
- - - - - Calculated weight, females.

There is a clear sex difference, the female having the heavier pancreas. Owing to the difficulty of dissection in the young rat the values between birth and 10 grams are not entered in table 147. The graph in chart 40 and the values in table 147 have been determined by formulas 25 and (25a).

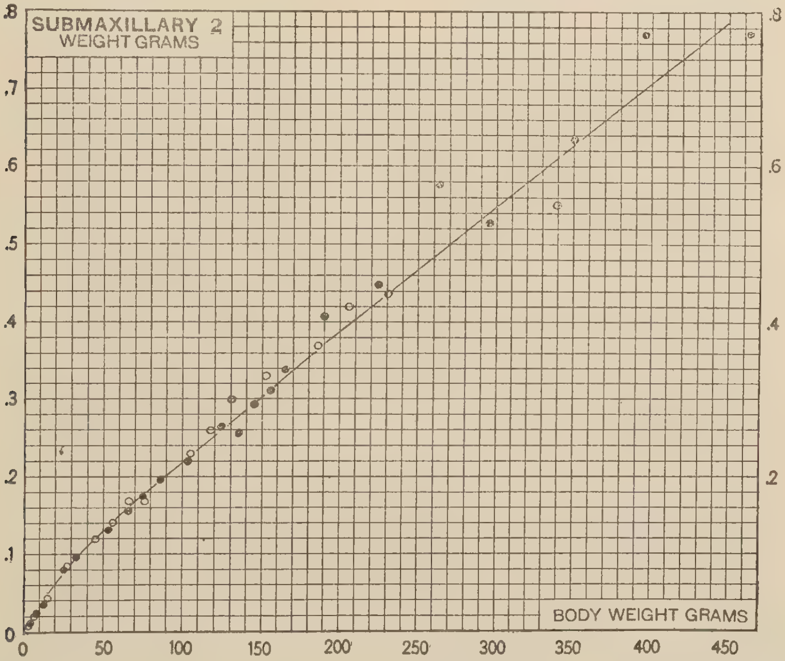

Chart 41 Showing the weight of submaxillary glands (2) of the albino rat according to body weight. The observed weights are represented by 152 male rats and 107 female rats, entered according to the groups given in table 147, formula 26.

• Observed weight, male. ∘ Observed weight, female.
—— Calculated weight.

*The weight of the submaxillaries (2) on body weight.* Technic: These glands are easily isolated on account of their definite outline as well as their tough texture. Two or more lymphatic nodules are found beside the submaxillaries. These are to be excluded and are easily removed with sharp scissors. The graph in chart 41 and the values in table 147 have been determined by formula (26). Hatai '18.

The form of the graph is similar to that for most of the visceral organs. The relation between the weight of the submaxillaries and that of the body is, after 25 grams in body weight, practically linear. There is no indication of a sex difference so far as the weight is concerned.

*Weight of the thyroid gland on body weight.* Technic: Several minute muscles nearly the color of the gland must be removed before weighing. The data are from observations by Jackson ('13), as well as from those made at The Wistar Institute. A study of the data has not revealed any difference according to sex and the graph therefore is for both sexes combined. The graph in chart 42 and the values in table 148 have been determined by formula (39). Hatai ('13); Jackson ('13).

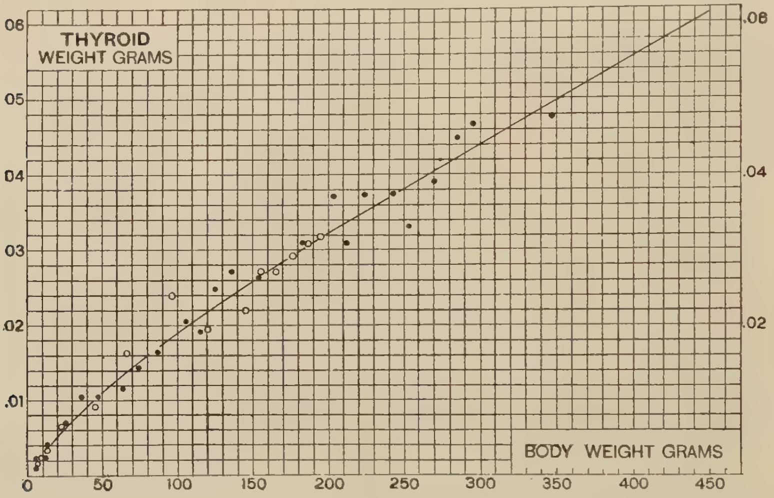

Chart 42 Showing the weight of thyroid gland of the albino rat according to body weight. The observed weights are represented by 42 (Jackson) female rats below 50 grams in body weight, and 49 (Wistar) male rats above 50 grams in body weight; and 36 (Jackson) female rats below 50 grams in body weight, and 27 (Wistar) female rats above 50 grams in body weight. Table 148, formula (39)

● Observed weight male. —— Calculated weight for both sexes. ○ Observed weight, female.

*The weight of the hypophysis on body weight.* Technic: After the removal of the brain, the hypophysis is readily picked up from the floor of the skull with a small forceps. It is weighed as removed.

At about 40–50 days of age there appears a difference in the weight of the hypophysis according to sex and with advancing age this difference tends to increase. The female has the heavier hypophysis. The graph for the male in chart 43 and the values for the male in table 148 have been determined by formula (35). The graph for the female and the corresponding tabular values by formulas (35) and (36). Hatai ('13).

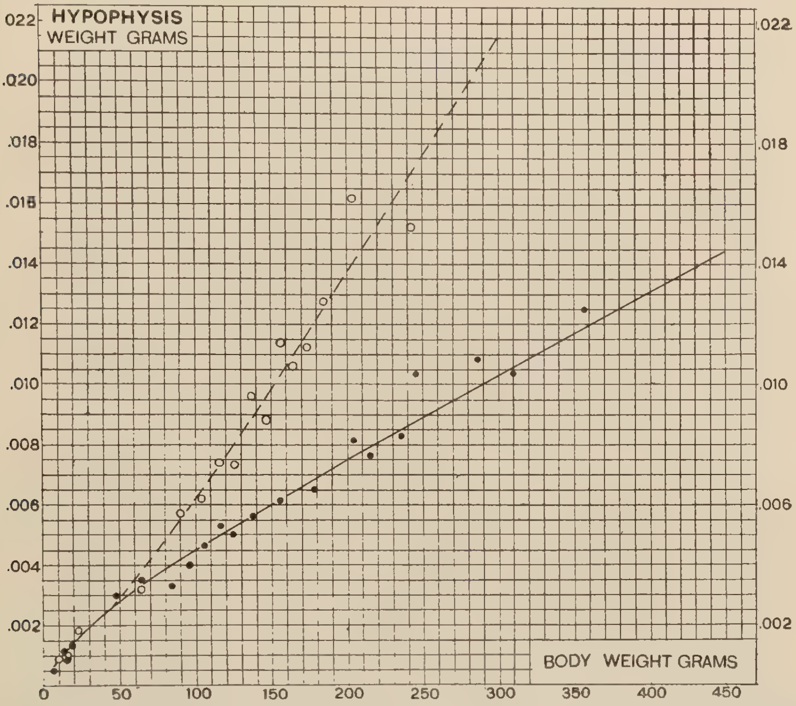

Chart 43 Showing the weight of hypophysis of the albino rat according to body weight. The observed weights are represented by 78 male and 80 female rats. Table 148, formulas (35) and (36).

● Observed weight, male. ○ Observed weight, female.
—— Calculated weight, male. ---- Calculated weight, female.

*The weight of the suprarenals on body weight.* Technic: The suprarenals are usually imbedded within some fat tissue—but with a little practice they may be dissected out cleanly. At about 40–50 days of age there appears a difference in the weight of the suprarenals according to sex and with advancing age this difference tends to increase. The female has the heavier suprarenals. The graph for the male in chart 44 and the values for the male in table 148 have been determined by formula (37). The graph for the female and the corresponding tabular values, by formula (38). Hatai ('13); Jackson ('13).

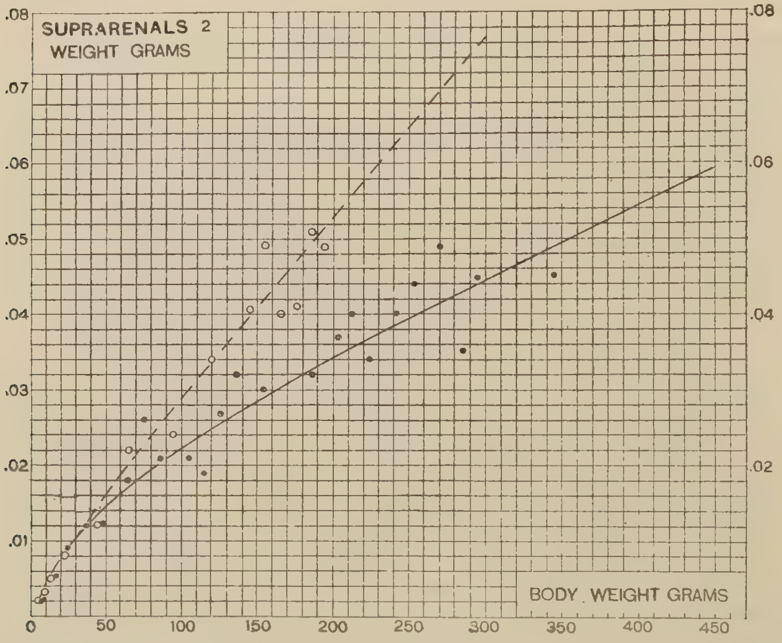

Chart 44 Showing the weight of suprarenals of the albino rat according to body weight. The observed weights are represented by 92 (Jackson) male rats below 50 grams in body weight, and 53 (Wistar) male rats above 50 grams in body weight; and 84 (Jackson) female rats below 50 grams in body weight, and 29 (Wistar) female rats above 50 grams in body weight. Table 148, formulas (37) and (38).

- ● Observed weight, male.
- —— Calculated weight, male.
- ○ Observed weight, female.
- - - - - Calculated weight, female.

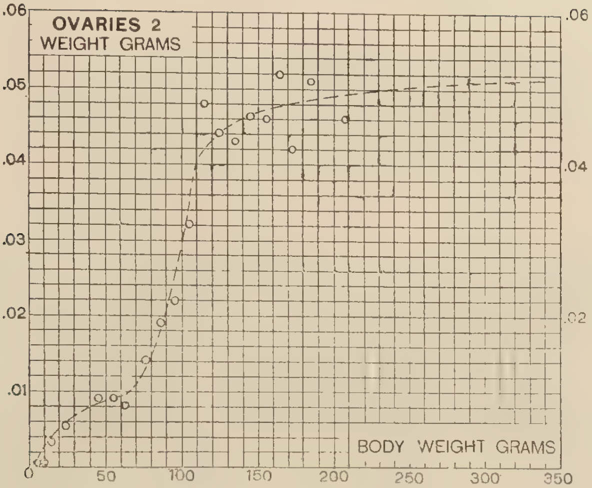

Chart 45 Showing the weight of ovaries of the unmated female albino rat according to body weight. The observed weights are represented by 136 (Jackson) rats. Table 146, formulas (32), (33) and (34).

• Observed weight. ---- Calculated weight.

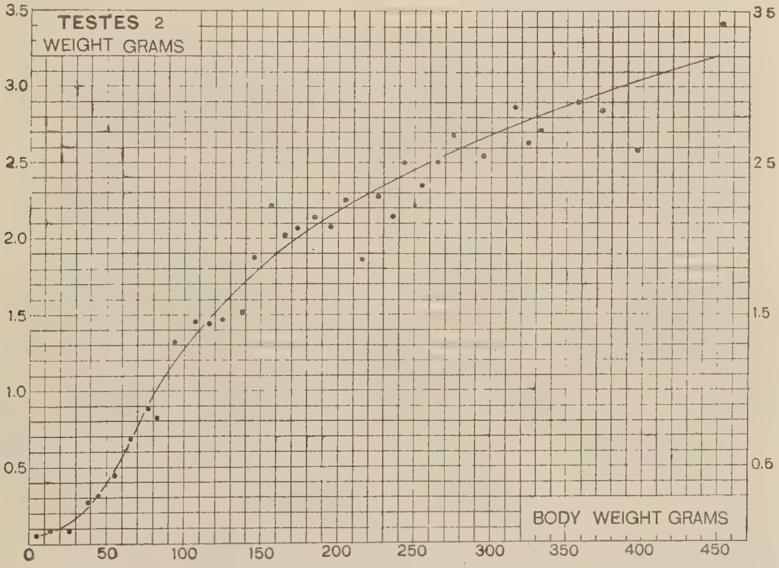

Chart 46 Showing the weight of testes of the male albino rat according to body weight. The observed weights are represented by 121 male rats. Table 146, formulas (27), (28) and (29).

• Observed weight. —— Calculated weight.

6. *The third group of the organs here considered is formed by those the growth of which is represented by a sinuous graph in which the most marked rise appears shortly before puberty. These organs, so far as examined, are the ovaries, the testes, epididymis and the thymus.*

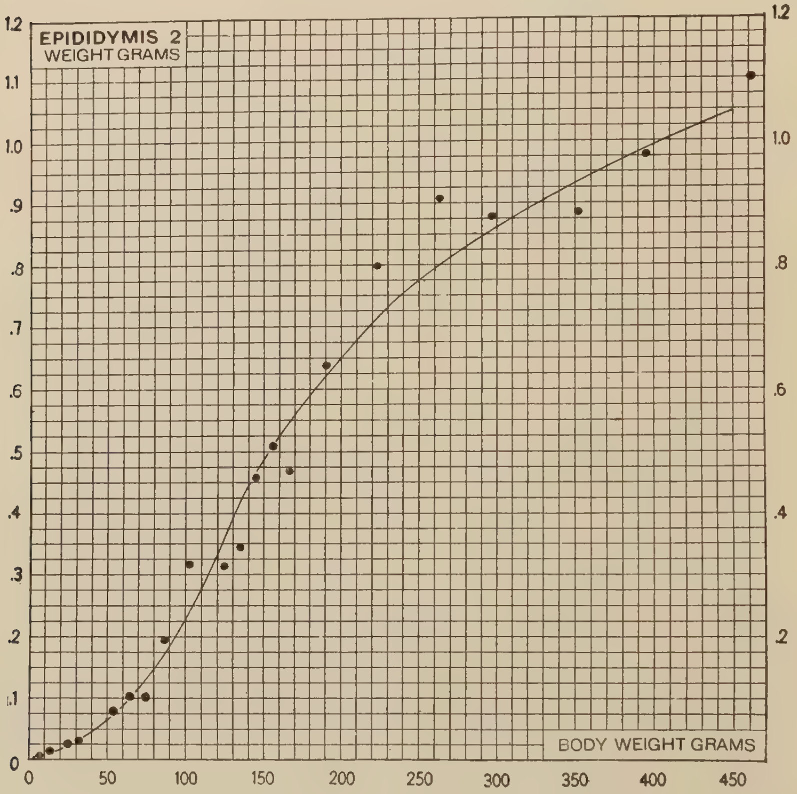

Chart 47 Showing the weight of epididymides of the male albino rat according to body weight. The observed weights are represented by 152 rats entered according to the groups given in table 147, formulas (30) and (31).

• Observed weight. —— Calculated weight.

*The weight of both ovaries on the body weight.* Technic: The ovaries must be carefully dissected from their capsules and from the end of the fallopian tube. When the animal is small it is sometimes necessary to do this under a dissecting microscope. The data collected by Jackson ('13), for unmated females, are those used. The graph in chart 45 and the values in table 146 have been determined by formulas (32), (33), and (34). Hatai ('13, '14a); Jackson ('13).

*The weight of both testes on body weight.* Technic: The epididymis (2) was removed before the testes were weighed. The graph in chart 46 and the values in table 146 were determined by formulas (27) (28) and (29). Hatai ('13); Jackson ('13).

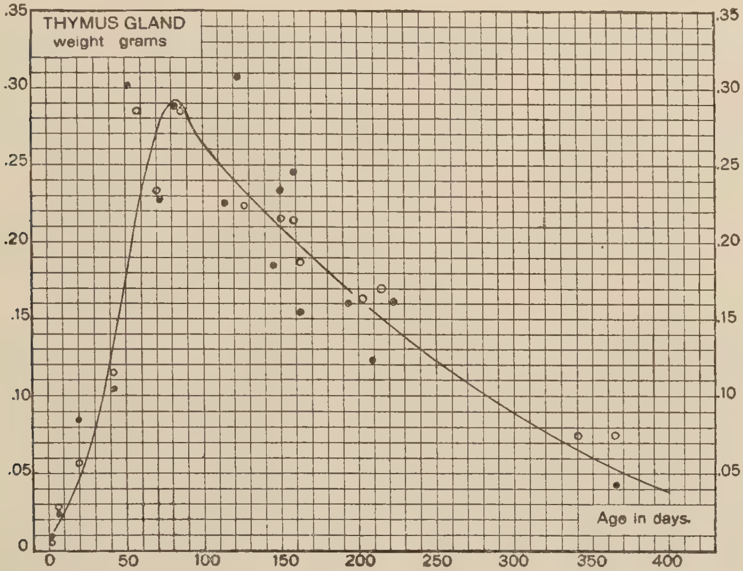

Chart 48 Showing the weight of the thymus of the albino rat according to age. The observed weights are represented by 229 males (164 Jackson and 64 Wistar) and 207 females (179 Jackson and 28 Wistar). Table 15, formulas (45) and (46).

Observed weight, • male, ○ female, ——Computed weight.

*The weight of both epididymides.* Technic: The epididymis of the adult rats is usually surrounded by a mass of fat. To separate the adipose tissue the caudal end of the organ is held firmly with strong forceps and then along the entire length of the epididymis this tissue is cut away with sharp scissors, care being taken not to injure the organ itself. A complete isolation of the fat is impossible, but the organ can be so nearly freed that the adhering particles do not modify the results.

The graph in chart 47 and the values in table 147 were determined by the formulas (30) and (31). (Hatai, '18).

*Weight of thymus on age.* In the case of the thymus the data are more useful when presented according to age than when presented according to body weight.

Technic: In preparing the thymus care must be taken to dissect away the large lymph glands as well as the fat lying about it. The records by Jackson ('13) have been combined with those from The Wistar Institute. The graph in chart 48 and the values in table 151 have been determined by the formulas (45) and (46). No weight difference according to sex has been noted. Hatai ('14); Jackson ('13).

7. *Variability. Variation in body weight and organ weight.* In table 141 Jackson ('13) gives a series of determinations of the coefficient of variation for body weight on a litter basis and in age groups. The animals were selected by the method of "random sampling." These values are to be compared with those determined by King—table 121.

For the same animals as were used in table 141 Jackson ('13) also gives for the several organs the coefficients of variation (table 142) and the coefficients of correlation with the body weight (table 143).

8. *General tables.* The tables which are not represented by charts in the text are usually short and have been introduced where they are mentioned, but as a matter of convenience all of those which are so represented are here grouped together as general tables under the following heads:

Tables for the increase in the weight of the entire body, brain and spinal cord on age—tables 157, and 157 a.

TABLE 141

*Coefficient of variation in body weight for total population by the ordinary method, and on litter basis (fraternal variation) estimated by various methods (Jackson, '13).*

| | SEX | NEW-BORN | 7 DAYS | 20 DAYS | 6 WEEKS | 10 WEEKS | 5 MONTHS |
|---|---|---|---|---|---|---|---|
| Total population.......... (ordinary method) | Male | 13.6* | 16.9* | 24.4** | 20.8** | 18.8* | 18.5* |
| | Female | 9.9* | 13.7* | 29.4* | 24.2* | 16.8* | 15.3* |
| Litter basis.............. (average of litters calculated by ordinary method) | Male | 7.0 | 6.1 | 5.7 | 6.6 | 5.8 | 7.4 |
| | Female | 4.4 | 5.4 | 4.0 | 5.9 | 12.0 | 10.4 |
| Litter basis................ (calculated from Yule's formula) | Male | 6.8 | 7.6 | 6.8 | 7.1 | 6.1 | 8.1 |
| | Female | 5.2 | 4.4 | 4.5 | 7.9 | 12.2 | 9.3 |
| Litter basis................ (from Kellogg's formula) | Male | 7.3 | 8.4 | 6.0 | 7.2 | 6.7 | 8.5 |
| | Female | 5.2 | 4.5 | 4.1 | 8.5 | 12.0 | 9.0 |

* For net body weight.

** For gross body weight, larger series.

TABLE 142

*Coefficients of variation in organ weights, albino rat at different ages. Arranged according to mean values in the last column (Jackson, '12)*

| | 0 DAYS | 7 DAYS | 21 DAYS | 42 DAYS | 70 DAYS | 150 DAYS | AVERAGE |
|---|---|---|---|---|---|---|---|
| Brain............. | 12 | | 7 | 12 | | | 10 |
| Eyeballs........... | 16 | 15 | 13 | 8 | 11 | 9 | 12 |
| Head.............. | 10 | 11 | 15 | 10 | 14 | 13 | 12 |
| Total body........ | 12 | 16 | 28 | 21 | 20 | 19 | 19 |
| Lungs.............. | 23 | 17 | 24 | 19 | 21 | | 21 |
| Kidneys............ | 24 | 22 | 34 | 15 | 17 | 19 | 22 |
| Heart............. | 18 | 20 | 34 | 30 | 18 | 21 | 24 |
| Liver.............. | 22 | 19 | 41 | 19 | 33 | 25 | 26 |
| Suprarenals....... | 24 | 20 | 33 | 22 | 21 | 39 | 26 |
| Testes............ | 25 | 18 | 30 | 27 | 35 | 41 | 29 |
| Thymus........... | 31 | 32 | 43 | 50 | 25 | 22 | 34 |
| Spleen............. | 39 | 34 | 51 | 26 | 38 | 19 | 34 |
| Intestinal canal (plus contents) | 38 | 29 | 42 | 30 | | | 35 |
| Ovaries........... | | | 42 | 47 | 51 | 33 | 43 |
| Average of viscera | 23 | 22 | 31 | 24 | 26 | 24 | 25 |

Tables for the increase in the length of the tail, in the weight of the entire body, and in the weight of several of the viscera according to body length—tables 144–148 and 152.

Also a series of crude tables giving the directly observed weights of a series of small organs on body weight and age—tables 149 and 150.

Jackson ('13) and others have called attention to discrepancies between their observed values and those in table 148.

TABLE 143

*Coefficients of correlation of organ weights with the body weight: albino rat at different ages. Arranged according to mean values in the last column (Jackson, '13)*

| | 0 DAYS | 7 DAYS | 21 DAYS | 42 DAYS | 70 DAYS | 150 DAYS | AVERAGE |
|---|---|---|---|---|---|---|---|
| Head | 0.76 | 0.89 | 0.93 | 0.95 | 0.75 | 0.85 | 0.86 |
| Kidneys | 0.70 | 0.79 | 0.96 | 0.92 | 0.90 | 0.91 | 0.86 |
| Liver | 0.76 | 0.76 | 0.97 | 0.84 | 0.74 | 0.87 | 0.83 |
| Lungs | 0.74 | 0.80 | 0.87 | 0.94 | 0.62 | | 0.80 |
| Brain | 0.69 | | 0.78 | 0.88 | | | 0.78 |
| Heart | 0.58 | 0.50 | 0.91 | 0.97 | 0.86 | 0.84 | 0.78 |
| Testes | 0.67 | 0.75 | 0.95 | 0.75 | 0.48 | 0.88 | 0.75 |
| Ovaries | | | 0.73 | 0.64 | 0.82 | 0.81 | 0.75 |
| Intestinal canal (plus contents) | 0.29 | 0.59 | 0.84 | 0.76 | | | 0.62 |
| Thymus | 0.67 | 0.74 | 0.89 | 0.90 | 0.51 | −0.09 | 0.60 |
| Spleen | 0.54 | 0.44 | 0.97 | 0.50 | 0.41 | 0.46 | 0.55 |
| Eyeballs | 0.67 | 0.52 | 0.67 | 0.31 | 0.22 | 0.32 | 0.45 |
| Suprarenals | 0.51 | 0.13 | 0.58 | 0.41 | 0.41 | 0.35 | 0.40 |
| Average | 0.63 | 0.63 | 0.85 | 0.75 | 0.62 | 0.70 | 0.70 |

On careful consideration it appears that the values in the tables are those characteristic for the special strain which was used, and the original table values have therefore been retained unaltered. That other strains may give other values is of course to be recognized and also the high variability of these organs, especially the endocrine glands, must always be kept in mind.

Table 151 for the weight of the thymus—is based not on body length but on age.

Weight of all the viscera combined—table 153.

Tables giving the values for characters other than body weight, linked with age—tables 151 and 157.

For the most part the tables are preceded by a slight descriptive heading only. Reference is made to the corresponding charts in connection with which all the details concerning them have been noted.

*Tables showing the increase in the weight of the entire body with age.*

Growth before birth—Stotsenburg ('15) tables 118 and 119, chart 20.

Postnatal growth in body weight is recorded in tables 157, charts 21 and 22, and 157 A.

*The body weights in table 157 are those which were used for our so-called "standard curve of growth" as shown in charts 21*A *and 22a.*

The data in table 157A are those on which the graph published by Greenman and Duhring ('23) is based. They are here tabulated because they represent the age-body weight relations now found in the colony of The Wistar Institute and in general are decidedly above those used for our standard curve of growth. These high values are the result of special care and feeding, coupled with selection, and surpass those commonly obtained under the usual conditions.

*Tables giving characters other than body weight which depend primarily on age.*

Table 157 gives the percentage of water in the brain and in the spinal cord for each sex from birth to 365 days. These values have been computed by formulas (47)–(49a) and (50)–(52d) The graphs corresponding to these data for the males are given in chart 55.

Table 151 gives the values for the weight of the thymus—sexes combined—from birth to 400 days. The values have been computed by formulas (45) and (46). The graph corresponding to these data is given in chart 48.

The five tables 144–148 which follow have been worked out on the basis of body length by the use of the appropriate formulas. The details touching the organs represented, as well as the corresponding graphs, are given earlier in this chapter.

TABLE 144

*Giving for each sex the tail length and the weights of the brain, spinal cord and both eyeballs for each millimeter of body length. See Charts 27, 28, 29, 30 and 31*

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight in gms. | | Both eye-balls | Tail length | Body weight | Weight in gms. | | Both eye-balls |
| | | | Brain | Spinal cord | | | | Brain | Spinal cord | |
| *mm.* | *mm.* | *gms.* | | | *gms.* | *mm.* | *gms.* | | | *gms.* |
| 47 | 14.9 | 4.9 | 0.226 | 0.033 | 0.029 | 15.4 | 4.7 | 0.211 | 0.033 | 0.028 |
| 48 | 15.8 | 4.9 | 0.226 | 0.033 | 0.029 | 16.6 | 4.7 | 0.214 | 0.033 | 0.028 |
| 49 | 16.9 | 5.0 | 0.232 | 0.034 | 0.030 | 17.8 | 4.9 | 0.217 | 0.034 | 0.029 |
| 50 | 18.0 | 5.1 | 0.238 | 0.034 | 0.031 | 19.0 | 5.0 | 0.222 | 0.035 | 0.029 |
| 51 | 19.2 | 5.2 | 0.252 | 0.035 | 0.031 | 20.2 | 5.1 | 0.227 | 0.035 | 0.030 |
| 52 | 20.4 | 5.3 | 0.266 | 0.036 | 0.032 | 21.5 | 5.3 | 0.255 | 0.036 | 0.032 |
| 53 | 21.6 | 5.4 | 0.280 | 0.037 | 0.033 | 22.7 | 5.5 | 0.283 | 0.038 | 0.034 |
| 54 | 22.7 | 5.6 | 0.300 | 0.038 | 0.034 | 23.9 | 5.8 | 0.323 | 0.041 | 0.036 |
| 55 | 23.9 | 5.8 | 0.320 | 0.040 | 0.036 | 25.2 | 6.2 | 0.361 | 0.044 | 0.039 |
| 56 | 25.0 | 6.1 | 0.358 | 0.043 | 0.039 | 26.4 | 6.5 | 0.398 | 0.048 | 0.041 |
| 57 | 26.2 | 6.4 | 0.395 | 0.046 | 0.041 | 27.6 | 6.9 | 0.433 | 0.051 | 0.044 |
| 58 | 27.3 | 6.8 | 0.431 | 0.049 | 0.044 | 28.8 | 7.2 | 0.468 | 0.054 | 0.046 |
| 59 | 28.5 | 7.1 | 0.465 | 0.052 | 0.046 | 30.0 | 7.6 | 0.500 | 0.057 | 0.049 |
| 60 | 29.6 | 7.5 | 0.498 | 0.055 | 0.048 | 31.2 | 8.0 | 0.532 | 0.061 | 0.051 |
| 61 | 30.7 | 7.9 | 0.530 | 0.059 | 0.050 | 32.3 | 8.4 | 0.564 | 0.064 | 0.053 |
| 62 | 31.9 | 8.2 | 0.561 | 0.062 | 0.052 | 33.5 | 8.7 | 0.594 | 0.068 | 0.055 |
| 63 | 33.0 | 8.6 | 0.591 | 0.065 | 0.054 | 34.7 | 9.1 | 0.624 | 0.071 | 0.057 |
| 64 | 34.1 | 9.0 | 0.621 | 0.068 | 0.056 | 35.9 | 9.5 | 0.652 | 0.074 | 0.059 |
| 65 | 35.2 | 9.4 | 0.650 | 0.071 | 0.058 | 37.0 | 9.9 | 0.679 | 0.077 | 0.061 |
| 66 | 36.3 | 9.8 | 0.678 | 0.075 | 0.060 | 38.2 | 10.3 | 0.703 | 0.081 | 0.063 |
| 67 | 37.4 | 10.1 | 0.695 | 0.078 | 0.062 | 39.4 | 10.8 | 0.726 | 0.084 | 0.065 |
| 68 | 38.5 | 10.6 | 0.711 | 0.081 | 0.064 | 40.5 | 11.2 | 0.772 | 0.088 | 0.067 |
| 69 | 39.6 | 11.0 | 0.761 | 0.084 | 0.066 | 41.7 | 11.6 | 0.811 | 0.091 | 0.068 |
| 70 | 40.7 | 11.4 | 0.803 | 0.088 | 0.068 | 42.8 | 12.0 | 0.846 | 0.095 | 0.070 |
| 71 | 41.8 | 11.8 | 0.840 | 0.091 | 0.069 | 43.9 | 12.5 | 0.876 | 0.098 | 0.072 |
| 72 | 42.9 | 12.2 | 0.872 | 0.094 | 0.071 | 45.1 | 12.9 | 0.904 | 0.101 | 0.073 |
| 73 | 44.0 | 12.7 | 0.901 | 0.098 | 0.073 | 46.2 | 13.4 | 0.929 | 0.105 | 0.075 |
| 74 | 45.1 | 13.1 | 0.928 | 0.101 | 0.074 | 47.3 | 13.9 | 0.952 | 0.108 | 0.077 |
| 75 | 46.2 | 13.6 | 0.952 | 0.104 | 0.076 | 48.5 | 14.3 | 0.974 | 0.112 | 0.078 |
| 76 | 47.2 | 14.0 | 0.974 | 0.107 | 0.077 | 49.6 | 14.8 | 0.994 | 0.115 | 0.080 |
| 77 | 48.3 | 14.5 | 0.995 | 0.111 | 0.079 | 50.7 | 15.3 | 1.013 | 0.119 | 0.082 |
| 78 | 49.4 | 15.0 | 1.015 | 0.114 | 0.081 | 51.8 | 15.8 | 1.031 | 0.122 | 0.083 |
| 79 | 50.4 | 15.4 | 1.033 | 0.117 | 0.082 | 52.9 | 16.3 | 1.047 | 0.126 | 0.085 |
| 80 | 51.5 | 15.9 | 1.051 | 0.121 | 0.084 | 54.0 | 16.8 | 1.064 | 0.129 | 0.086 |

TABLE 144—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight in gms. | | Both eye-balls | Tail length | Body weight | Weight in gms. | | Both eye-balls |
| | | | Brain | Spinal cord | | | | Brain | Spinal cord | |
| *mm.* | *mm.* | *gms.* | | | *gms.* | *mm.* | *gms.* | | | *gms.* |
| 81 | 52.6 | 16.4 | 1.067 | 0.124 | 0.085 | 55.1 | 17.3 | 1.079 | 0.133 | 0.088 |
| 82 | 53.6 | 16.9 | 1.083 | 0.128 | 0.087 | 56.3 | 17.9 | 1.093 | 0.136 | 0.089 |
| 83 | 54.7 | 17.4 | 1.098 | 0.131 | 0.088 | 57.4 | 18.4 | 1.107 | 0.140 | 0.091 |
| 84 | 55.7 | 18.0 | 1.112 | 0.134 | 0.090 | 58.5 | 19.0 | 1.121 | 0.143 | 0.093 |
| 85 | 56.8 | 18.5 | 1.126 | 0.138 | 0.091 | 59.5 | 19.5 | 1.134 | 0.147 | 0.094 |
| 86 | 57.8 | 19.0 | 1.139 | 0.141 | 0.093 | 60.6 | 20.1 | 1.146 | 0.150 | 0.095 |
| 87 | 58.9 | 19.6 | 1.152 | 0.144 | 0.094 | 61.7 | 20.7 | 1.159 | 0.154 | 0.097 |
| 88 | 59.9 | 20.1 | 1.165 | 0.148 | 0.095 | 62.8 | 21.2 | 1.170 | 0.158 | 0.098 |
| 89 | 61.0 | 20.7 | 1.177 | 0.151 | 0.097 | 63.9 | 21.8 | 1.181 | 0.161 | 0.100 |
| 90 | 62.0 | 21.3 | 1.188 | 0.155 | 0.098 | 65.0 | 22.4 | 1.193 | 0.165 | 0.101 |
| 91 | 63.0 | 21.9 | 1.200 | 0.158 | 0.100 | 66.1 | 23.1 | 1.203 | 0.168 | 0.103 |
| 92 | 64.1 | 22.4 | 1.211 | 0.162 | 0.101 | 67.2 | 23.7 | 1.214 | 0.172 | 0.104 |
| 93 | 65.1 | 23.0 | 1.221 | 0.165 | 0.102 | 68.2 | 24.3 | 1.224 | 0.176 | 0.105 |
| 94 | 66.2 | 23.7 | 1.231 | 0.168 | 0.104 | 69.3 | 25.0 | 1.234 | 0.179 | 0.107 |
| 95 | 67.2 | 24.3 | 1.242 | 0.172 | 0.105 | 70.4 | 25.6 | 1.244 | 0.183 | 0.108 |
| 96 | 68.2 | 24.9 | 1.252 | 0.175 | 0.107 | 71.4 | 26.3 | 1.253 | 0.186 | 0.109 |
| 97 | 69.2 | 25.6 | 1.261 | 0.179 | 0.108 | 72.5 | 27.0 | 1.262 | 0.190 | 0.111 |
| 98 | 70.3 | 26.2 | 1.271 | 0.182 | 0.109 | 73.6 | 27.7 | 1.271 | 0.194 | 0.112 |
| 99 | 71.3 | 26.9 | 1.280 | 0.186 | 0.111 | 74.6 | 28.4 | 1.280 | 0.197 | 0.114 |
| 100 | 72.3 | 27.5 | 1.289 | 0.189 | 0.112 | 75.7 | 29.1 | 1.289 | 0.201 | 0.115 |
| 101 | 73.3 | 28.2 | 1.298 | 0.193 | 0.113 | 76.8 | 29.8 | 1.298 | 0.205 | 0.116 |
| 102 | 74.3 | 28.9 | 1.307 | 0.197 | 0.115 | 77.8 | 30.5 | 1.306 | 0.209 | 0.118 |
| 103 | 75.4 | 29.6 | 1.315 | 0.200 | 0.116 | 78.9 | 31.3 | 1.314 | 0.212 | 0.119 |
| 104 | 76.4 | 30.3 | 1.323 | 0.204 | 0.117 | 79.9 | 32.0 | 1.322 | 0.216 | 0.120 |
| 105 | 77.4 | 31.1 | 1.332 | 0.207 | 0.119 | 81.0 | 32.8 | 1.330 | 0.220 | 0.122 |
| 106 | 78.4 | 31.8 | 1.340 | 0.211 | 0.120 | 82.0 | 33.6 | 1.338 | 0.223 | 0.123 |
| 107 | 79.4 | 32.5 | 1.348 | 0.214 | 0.121 | 83.1 | 34.4 | 1.346 | 0.227 | 0.124 |
| 108 | 80.4 | 33.3 | 1.356 | 0.218 | 0.123 | 84.1 | 35.2 | 1.354 | 0.231 | 0.126 |
| 109 | 81.4 | 34.1 | 1.363 | 0.221 | 0.124 | 85.2 | 36.0 | 1.361 | 0.235 | 0.127 |
| 110 | 82.4 | 34.9 | 1.371 | 0.225 | 0.125 | 86.2 | 36.9 | 1.368 | 0.238 | 0.128 |
| 111 | 83.4 | 35.7 | 1.378 | 0.228 | 0.126 | 87.3 | 37.7 | 1.376 | 0.242 | 0.130 |
| 112 | 84.4 | 36.5 | 1.386 | 0.232 | 0.128 | 88.3 | 38.6 | 1.383 | 0.246 | 0.131 |
| 113 | 85.4 | 37.3 | 1.393 | 0.236 | 0.129 | 89.4 | 39.5 | 1.390 | 0.250 | 0.132 |
| 114 | 86.4 | 38.2 | 1.400 | 0.239 | 0.130 | 90.4 | 40.3 | 1.397 | 0.253 | 0.134 |
| 115 | 87.4 | 39.0 | 1.407 | 0.243 | 0.132 | 91.4 | 41.3 | 1.404 | 0.257 | 0.135 |
| 116 | 88.4 | 39.9 | 1.414 | 0.246 | 0.133 | 92.5 | 42.2 | 1.411 | 0.261 | 0.136 |

TABLE 144—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight in gms. | | Both eye-balls | Tail length | Body weight | Weight in gms. | | Both eye-balls |
| | | | Brain | Spinal cord | | | | Brain | Spinal cord | |
| *mm.* | *mm.* | *gms.* | | | *gms.* | *mm.* | *gms.* | | | *gms.* |
| 117 | 89.4 | 40.8 | 1.421 | 0.250 | 0.134 | 93.5 | 43.1 | 1.418 | 0.265 | 0.138 |
| 118 | 90.4 | 41.6 | 1.428 | 0.254 | 0.136 | 94.5 | 44.1 | 1.424 | 0.268 | 0.139 |
| 119 | 91.4 | 42.6 | 1.435 | 0.257 | 0.137 | 95.6 | 45.0 | 1.431 | 0.272 | 0.140 |
| 120 | 92.4 | 43.5 | 1.442 | 0.261 | 0.138 | 96.6 | 46.0 | 1.438 | 0.276 | 0.142 |
| 121 | 93.4 | 44.4 | 1.448 | 0.265 | 0.140 | 97.6 | 47.0 | 1.444 | 0.280 | 0.143 |
| 122 | 94.4 | 45.4 | 1.455 | 0.268 | 0.141 | 98.7 | 48.0 | 1.450 | 0.284 | 0.144 |
| 123 | 95.4 | 46.3 | 1.461 | 0.272 | 0.142 | 99.7 | 49.1 | 1.457 | 0.287 | 0.146 |
| 124 | 96.4 | 47.3 | 1.468 | 0.276 | 0.143 | 100.7 | 50.1 | 1.463 | 0.291 | 0.147 |
| 125 | 97.4 | 48.3 | 1.474 | 0.279 | 0.145 | 101.7 | 51.2 | 1.469 | 0.295 | 0.148 |
| 126 | 98.4 | 49.3 | 1.480 | 0.283 | 0.146 | 102.8 | 52.3 | 1.476 | 0.299 | 0.150 |
| 127 | 99.3 | 50.4 | 1.487 | 0.287 | 0.147 | 103.8 | 53.4 | 1.482 | 0.303 | 0.151 |
| 128 | 100.3 | 51.4 | 1.493 | 0.290 | 0.149 | 104.8 | 54.5 | 1.488 | 0.307 | 0.153 |
| 129 | 101.3 | 52.5 | 1.499 | 0.294 | 0.150 | 105.8 | 55.6 | 1.494 | 0.310 | 0.154 |
| 130 | 102.3 | 53.6 | 1.505 | 0.297 | 0.151 | 106.8 | 56.8 | 1.500 | 0.314 | 0.155 |
| 131 | 103.3 | 54.7 | 1.511 | 0.301 | 0.153 | 107.9 | 58.0 | 1.506 | 0.318 | 0.157 |
| 132 | 104.2 | 55.8 | 1.517 | 0.305 | 0.154 | 108.9 | 59.2 | 1.512 | 0.322 | 0.158 |
| 133 | 105.2 | 56.9 | 1.523 | 0.309 | 0.155 | 109.9 | 60.4 | 1.518 | 0.326 | 0.159 |
| 134 | 106.2 | 58.1 | 1.529 | 0.312 | 0.157 | 110.9 | 61.6 | 1.523 | 0.330 | 0.161 |
| 135 | 107.2 | 59.3 | 1.535 | 0.316 | 0.158 | 111.9 | 62.9 | 1.529 | 0.334 | 0.162 |
| 136 | 108.2 | 60.5 | 1.541 | 0.320 | 0.160 | 112.9 | 64.2 | 1.535 | 0.338 | 0.164 |
| 137 | 109.1 | 61.7 | 1.546 | 0.323 | 0.161 | 114.0 | 65.5 | 1.540 | 0.341 | 0.165 |
| 138 | 110.1 | 62.9 | 1.552 | 0.327 | 0.162 | 115.0 | 66.8 | 1.546 | 0.345 | 0.166 |
| 139 | 111.1 | 64.1 | 1.558 | 0.331 | 0.164 | 116.0 | 68.1 | 1.552 | 0.349 | 0.168 |
| 140 | 112.1 | 65.4 | 1.563 | 0.335 | 0.165 | 117.0 | 69.5 | 1.557 | 0.353 | 0.169 |
| 141 | 113.0 | 66.7 | 1.569 | 0.338 | 0.166 | 118.0 | 70.9 | 1.563 | 0.357 | 0.171 |
| 142 | 114.0 | 68.0 | 1.575 | 0.342 | 0.168 | 119.0 | 72.3 | 1.568 | 0.361 | 0.172 |
| 143 | 115.0 | 69.3 | 1.580 | 0.346 | 0.169 | 120.0 | 73.7 | 1.574 | 0.365 | 0.174 |
| 144 | 115.9 | 70.7 | 1.586 | 0.349 | 0.171 | 121.0 | 75.2 | 1.579 | 0.369 | 0.175 |
| 145 | 116.9 | 72.1 | 1.591 | 0.353 | 0.172 | 122.0 | 76.7 | 1.585 | 0.373 | 0.177 |
| 146 | 117.9 | 73.5 | 1.597 | 0.357 | 0.173 | 123.0 | 78.2 | 1.590 | 0.377 | 0.178 |
| 147 | 118.8 | 74.9 | 1.602 | 0.361 | 0.175 | 124.0 | 79.7 | 1.595 | 0.380 | 0.180 |
| 148 | 119.8 | 76.3 | 1.607 | 0.365 | 0.176 | 125.0 | 81.3 | 1.601 | 0.384 | 0.181 |
| 149 | 120.8 | 77.8 | 1.613 | 0.368 | 0.178 | 126.0 | 82.8 | 1.606 | 0.388 | 0.182 |
| 150 | 121.7 | 79.3 | 1.618 | 0.372 | 0.179 | 127.0 | 84.4 | 1.611 | 0.392 | 0.184 |
| 151 | 122.7 | 80.8 | 1.623 | 0.376 | 0.181 | 128.0 | 86.1 | 1.616 | 0.396 | 0.186 |
| 152 | 123.7 | 82.4 | 1.629 | 0.380 | 0.182 | 129.0 | 87.7 | 1.622 | 0.400 | 0.187 |

TABLE 144—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight in gms. | | Both eye-balls | Tail length | Body weight | Weight in gms. | | Both eye-balls |
| | | | Brain | Spinal cord | | | | Brain | Spinal cord | |
| *mm.* | *mm.* | *gms.* | | | *gms.* | *mm.* | *gms.* | | | *gms.* |
| 153 | 124.6 | 83.9 | 1.634 | 0.383 | 0.183 | 130.0 | 89.4 | 1.627 | 0.404 | 0.189 |
| 154 | 125.6 | 85.5 | 1.639 | 0.387 | 0.185 | 131.0 | 91.1 | 1.632 | 0.408 | 0.190 |
| 155 | 126.5 | 87.1 | 1.644 | 0.391 | 0.186 | 132.0 | 92.9 | 1.637 | 0.412 | 0.192 |
| 156 | 127.5 | 88.7 | 1.649 | 0.395 | 0.188 | 133.0 | 94.6 | 1.642 | 0.416 | 0.193 |
| 157 | 128.5 | 90.4 | 1.654 | 0.398 | 0.189 | 134.0 | 96.4 | 1.647 | 0.420 | 0.195 |
| 158 | 129.4 | 92.1 | 1.659 | 0.402 | 0.191 | 135.0 | 98.3 | 1.652 | 0.424 | 0.196 |
| 159 | 130.4 | 93.8 | 1.664 | 0.406 | 0.192 | 136.0 | 100.1 | 1.657 | 0.428 | 0.198 |
| 160 | 131.3 | 95.6 | 1.670 | 0.410 | 0.194 | 137.0 | 102.0 | 1.662 | 0.432 | 0.200 |
| 161 | 132.3 | 97.3 | 1.675 | 0.414 | 0.196 | 137.9 | 103.9 | 1.667 | 0.436 | 0.201 |
| 162 | 133.3 | 99.2 | 1.680 | 0.417 | 0.197 | 138.9 | 105.9 | 1.672 | 0.440 | 0.203 |
| 163 | 134.2 | 101.0 | 1.685 | 0.421 | 0.199 | 139.9 | 107.9 | 1.677 | 0.444 | 0.204 |
| 164 | 135.2 | 102.8 | 1.690 | 0.425 | 0.200 | 140.9 | 109.9 | 1.682 | 0.448 | 0.206 |
| 165 | 136.1 | 104.7 | 1.695 | 0.429 | 0.202 | 141.9 | 111.9 | 1.687 | 0.452 | 0.208 |
| 166 | 137.1 | 106.7 | 1.699 | 0.433 | 0.203 | 142.9 | 114.0 | 1.692 | 0.456 | 0.209 |
| 167 | 138.0 | 108.6 | 1.704 | 0.436 | 0.205 | 143.9 | 116.1 | 1.697 | 0.460 | 0.211 |
| 168 | 139.0 | 110.6 | 1.709 | 0.440 | 0.207 | 144.9 | 118.3 | 1.702 | 0.464 | 0.213 |
| 169 | 139.9 | 112.6 | 1.714 | 0.444 | 0.208 | 145.9 | 120.5 | 1.707 | 0.468 | 0.215 |
| 170 | 140.9 | 114.8 | 1.719 | 0.448 | 0.210 | 146.8 | 122.7 | 1.711 | 0.472 | 0.216 |
| 171 | 141.8 | 116.7 | 1.724 | 0.452 | 0.212 | 147.8 | 125.0 | 1.716 | 0.476 | 0.218 |
| 172 | 142.8 | 118.9 | 1.729 | 0.456 | 0.213 | 148.8 | 127.3 | 1.721 | 0.480 | 0.220 |
| 173 | 143.7 | 121.0 | 1.734 | 0.459 | 0.215 | 149.8 | 129.6 | 1.726 | 0.484 | 0.222 |
| 174 | 144.7 | 123.2 | 1.738 | 0.463 | 0.217 | 150.8 | 132.0 | 1.731 | 0.488 | 0.223 |
| 175 | 145.6 | 125.4 | 1.743 | 0.467 | 0.218 | 151.8 | 134.4 | 1.735 | 0.492 | 0.225 |
| 176 | 146.6 | 127.7 | 1.748 | 0.471 | 0.220 | 152.7 | 136.8 | 1.740 | 0.496 | 0.227 |
| 177 | 147.5 | 130.0 | 1.753 | 0.475 | 0.222 | 153.7 | 139.3 | 1.745 | 0.500 | 0.229 |
| 178 | 148.5 | 132.3 | 1.757 | 0.479 | 0.224 | 154.7 | 141.9 | 1.750 | 0.504 | 0.231 |
| 179 | 149.4 | 134.6 | 1.762 | 0.483 | 0.225 | 155.7 | 144.4 | 1.754 | 0.508 | 0.232 |
| 180 | 150.4 | 137.0 | 1.767 | 0.486 | 0.227 | 156.7 | 147.1 | 1.759 | 0.512 | 0.234 |
| 181 | 151.3 | 139.5 | 1.771 | 0.490 | 0.229 | 157.6 | 149.7 | 1.764 | 0.516 | 0.236 |
| 182 | 152.3 | 142.0 | 1.776 | 0.494 | 0.231 | 158.6 | 152.4 | 1.768 | 0.520 | 0.238 |
| 183 | 153.2 | 144.5 | 1.781 | 0.498 | 0.233 | 159.6 | 155.2 | 1.773 | 0.524 | 0.240 |
| 184 | 154.1 | 147.0 | 1.785 | 0.502 | 0.234 | 160.6 | 158.0 | 1.778 | 0.528 | 0.242 |
| 185 | 155.1 | 149.6 | 1.790 | 0.506 | 0.236 | 161.5 | 160.8 | 1.782 | 0.532 | 0.244 |
| 186 | 156.0 | 152.3 | 1.795 | 0.510 | 0.238 | 162.5 | 163.7 | 1.787 | 0.536 | 0.246 |
| 187 | 157.0 | 155.0 | 1.799 | 0.513 | 0.240 | 163.5 | 166.6 | 1.791 | 0.540 | 0.248 |
| 188 | 157.9 | 157.7 | 1.804 | 0.517 | 0.242 | 164.5 | 169.6 | 1.796 | 0.544 | 0.250 |

TABLE 144—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight in gms. | | Both eye-balls | Tail length | Body weight | Weight in gms. | | Both eye-balls |
| | | | Brain | Spinal cord | | | | Brain | Spinal cord | |
| *mm.* | *mm.* | *gms.* | | | *gms.* | *mm.* | *gms.* | | | *gms.* |
| 189 | 158.9 | 160.5 | 1.808 | 0.521 | 0.244 | 165.4 | 172.6 | 1.801 | 0.548 | 0.252 |
| 190 | 159.8 | 163.3 | 1.813 | 0.525 | 0.246 | 166.4 | 175.7 | 1.805 | 0.552 | 0.254 |
| 191 | 160.7 | 166.2 | 1.818 | 0.529 | 0.248 | 167.4 | 178.8 | 1.810 | 0.556 | 0.256 |
| 192 | 161.7 | 169.1 | 1.822 | 0.533 | 0.250 | 168.4 | 182.0 | 1.814 | 0.560 | 0.258 |
| 193 | 162.6 | 172.0 | 1.827 | 0.537 | 0.252 | 169.3 | 185.2 | 1.819 | 0.564 | 0.261 |
| 194 | 163.6 | 175.0 | 1.831 | 0.541 | 0.254 | 170.3 | 188.5 | 1.823 | 0.569 | 0.263 |
| 195 | 164.5 | 178.1 | 1.836 | 0.545 | 0.256 | 171.3 | 191.9 | 1.828 | 0.573 | 0.265 |
| 196 | 165.4 | 181.2 | 1.840 | 0.548 | 0.258 | 172.2 | 195.3 | 1.832 | 0.577 | 0.267 |
| 197 | 166.4 | 184.3 | 1.845 | 0.552 | 0.260 | 173.2 | 198.7 | 1.837 | 0.581 | 0.269 |
| 198 | 167.3 | 187.5 | 1.849 | 0.556 | 0.262 | 174.2 | 202.2 | 1.841 | 0.585 | 0.272 |
| 199 | 168.3 | 190.8 | 1.854 | 0.560 | 0.264 | 175.1 | 205.8 | 1.846 | 0.589 | 0.274 |
| 200 | 169.2 | 194.1 | 1.858 | 0.564 | 0.266 | 176.1 | 209.4 | 1.850 | 0.593 | 0.276 |
| 201 | 170.1 | 197.4 | 1.863 | 0.568 | 0.268 | 177.1 | 213.1 | 1.855 | 0.597 | 0.278 |
| 202 | 171.1 | 200.8 | 1.867 | 0.572 | 0.271 | 178.0 | 216.8 | 1.859 | 0.601 | 0.281 |
| 203 | 172.0 | 204.3 | 1.872 | 0.576 | 0.273 | 179.0 | 220.7 | 1.864 | 0.605 | 0.283 |
| 204 | 172.9 | 207.8 | 1.876 | 0.579 | 0.275 | 180.0 | 224.5 | 1.868 | 0.609 | 0.286 |
| 205 | 173.9 | 211.4 | 1.880 | 0.583 | 0.277 | 180.9 | 228.4 | 1.872 | 0.613 | 0.288 |
| 206 | 174.8 | 215.0 | 1.885 | 0.587 | 0.280 | 181.9 | 232.4 | 1.877 | 0.617 | 0.290 |
| 207 | 175.7 | 218.7 | 1.889 | 0.591 | 0.282 | 182.9 | 236.5 | 1.881 | 0.621 | 0.293 |
| 208 | 176.7 | 222.5 | 1.894 | 0.595 | 0.284 | 183.8 | 240.6 | 1.886 | 0.625 | 0.295 |
| 209 | 177.6 | 226.3 | 1.898 | 0.599 | 0.288 | 184.8 | 244.8 | 1.890 | 0.630 | 0.298 |
| 210 | 178.5 | 230.2 | 1.903 | 0.603 | 0.289 | 185.8 | 249.1 | 1.894 | 0.634 | 0.301 |
| 211 | 179.5 | 234.1 | 1.907 | 0.607 | 0.291 | 186.7 | 253.4 | 1.899 | 0.638 | 0.303 |
| 212 | 180.4 | 238.1 | 1.911 | 0.611 | 0.294 | 187.7 | 257.8 | 1.903 | 0.642 | 0.306 |
| 213 | 181.3 | 242.2 | 1.916 | 0.615 | 0.296 | 188.7 | 262.3 | 1.908 | 0.646 | 0.308 |
| 214 | 182.3 | 246.3 | 1.920 | 0.619 | 0.299 | 189.6 | 266.9 | 1.912 | 0.650 | 0.311 |
| 215 | 183.2 | 250.5 | 1.924 | 0.623 | 0.301 | 190.6 | 271.5 | 1.916 | 0.654 | 0.314 |
| 216 | 184.1 | 254.7 | 1.929 | 0.626 | 0.304 | 191.5 | 276.2 | 1.921 | 0.658 | 0.317 |
| 217 | 185.0 | 259.1 | 1.933 | 0.630 | 0.306 | 192.5 | 281.0 | 1.925 | 0.662 | 0.319 |
| 218 | 186.0 | 263.5 | 1.937 | 0.634 | 0.309 | 193.5 | 285.8 | 1.929 | 0.666 | 0.322 |
| 219 | 186.9 | 267.9 | 1.942 | 0.638 | 0.312 | 194.4 | 290.8 | 1.934 | 0.670 | 0.325 |
| 220 | 187.8 | 272.5 | 1.946 | 0.642 | 0.314 | 195.4 | 295.8 | 1.938 | 0.675 | 0.328 |
| 221 | 188.8 | 277.1 | 1.950 | 0.646 | 0.317 | 196.3 | 300.9 | 1.942 | 0.679 | 0.331 |
| 222 | 189.7 | 281.8 | 1.955 | 0.650 | 0.320 | 197.3 | 306.1 | 1.947 | 0.683 | 0.334 |
| 223 | 190.6 | 286.5 | 1.959 | 0.654 | 0.322 | 198.3 | 311.3 | 1.951 | 0.687 | 0.337 |

TABLE 144—Concluded

| | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight in gms. | | Both eye-balls | Tail length | Body weight | Weight in gms. | | Both eye-balls |
| | | | Brain | Spinal cord | | | | Brain | Spinal cord | |
| *mm.* | *mm.* | *gms.* | | | *gms.* | *mm.* | *gms.* | | | *gms.* |
| 224 | 191.5 | 291.4 | 1.963 | 0.658 | 0.325 | 199.2 | 316.7 | 1.955 | 0.691 | 0.340 |
| 225 | 192.5 | 296.3 | 1.968 | 0.662 | 0.328 | 200.2 | 322.1 | 1.960 | 0.695 | 0.343 |
| 226 | 193.4 | 301.3 | 1.972 | 0.666 | 0.331 | 201.1 | 327.7 | 1.964 | 0.699 | 0.346 |
| 227 | 194.3 | 306.4 | 1.976 | 0.670 | 0.334 | 202.1 | 333.3 | 1.968 | 0.703 | 0.349 |
| 228 | 195.3 | 311.5 | 1.981 | 0.673 | 0.337 | 203.0 | 339.0 | 1.972 | 0.707 | 0.352 |
| 229 | 196.2 | 316.8 | 1.985 | 0.677 | 0.340 | 204.0 | 344.8 | 1.977 | 0.712 | 0.355 |
| 230 | 197.1 | 322.1 | 1.989 | 0.681 | 0.343 | 205.0 | 350.7 | 1.981 | 0.716 | 0.359 |
| 231 | 198.0 | 327.5 | 1.993 | 0.685 | 0.346 | 205.9 | 356.7 | 1.985 | 0.720 | 0.362 |
| 232 | 198.9 | 333.0 | 1.998 | 0.689 | 0.349 | 206.9 | 362.8 | 1.989 | 0.724 | 0.365 |
| 233 | 199.9 | 338.6 | 2.002 | 0.693 | 0.352 | 207.8 | 369.0 | 1.994 | 0.728 | 0.369 |
| 234 | 200.8 | 344.3 | 2.006 | 0.697 | 0.355 | 208.8 | 375.3 | 1.998 | 0.732 | 0.372 |
| 235 | 201.7 | 350.0 | 2.010 | 0.701 | 0.358 | 209.7 | 381.7 | 2.002 | 0.736 | 0.375 |
| 236 | 202.6 | 355.9 | 2.014 | 0.705 | 0.361 | 210.7 | 388.2 | 2.006 | 0.740 | 0.379 |
| 237 | 203.6 | 361.9 | 2.019 | 0.709 | 0.365 | 211.6 | 394.9 | 2.011 | 0.744 | 0.383 |
| 238 | 204.5 | 367.9 | 2.023 | 0.713 | 0.368 | 212.6 | 401.6 | 2.015 | 0.749 | 0.386 |
| 239 | 205.4 | 374.1 | 2.027 | 0.717 | 0.371 | 213.5 | 408.4 | 2.019 | 0.753 | 0.390 |
| 240 | 206.3 | 380.3 | 2.031 | 0.721 | 0.375 | 214.5 | 415.4 | 2.023 | 0.757 | 0.393 |
| 241 | 207.3 | 386.6 | 2.036 | 0.725 | 0.378 | 215.4 | 422.4 | 2.028 | 0.761 | 0.397 |
| 242 | 208.2 | 393.1 | 2.040 | 0.729 | 0.382 | 216.4 | 429.6 | 2.032 | 0.765 | 0.401 |
| 243 | 209.1 | 399.6 | 2.044 | 0.733 | 0.385 | 217.3 | 436.9 | 2.036 | 0.769 | 0.405 |
| 244 | 210.0 | 406.3 | 2.048 | 0.737 | 0.389 | 218.3 | 444.3 | 2.040 | 0.773 | 0.409 |
| 245 | 210.9 | 413.1 | 2.052 | 0.741 | 0.392 | 219.2 | 451.9 | 2.044 | 0.777 | 0.413 |
| 246 | 211.9 | 419.9 | 2.057 | 0.745 | 0.396 | 220.2 | 459.5 | 2.049 | 0.782 | 0.417 |
| 247 | 212.8 | 426.9 | 2.061 | 0.748 | 0.400 | 221.1 | 467.3 | 2.053 | 0.786 | 0.421 |
| 248 | 213.7 | 434.0 | 2.065 | 0.752 | 0.403 | 222.1 | 475.2 | 2.057 | 0.790 | 0.425 |
| 249 | 214.6 | 441.2 | 2.069 | 0.756 | 0.407 | 223.1 | 483.3 | 2.061 | 0.794 | 0.429 |
| 250 | 215.5 | 448.5 | 2.073 | 0.760 | 0.411 | 224.0 | 491.5 | 2.065 | 0.798 | 0.433 |

TABLE 145

*Giving for each sex the weights of body, heart, both kidneys, liver and spleen—for each millimeter of body length. See Charts 32, 33, 34 and 35*

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Heart | Both kidneys | Liver | Spleen | Body weight | Heart | Both kidneys | Liver | Spleen |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 47 | 4.9 | 0.031 | 0.046 | 0.21 | 0.009 | 4.7 | 0.030 | 0.046 | 0.20 | 0.008 |
| 48 | 4.9 | 0.031 | 0.047 | 0.21 | 0.009 | 4.7 | 0.030 | 0.046 | 0.20 | 0.008 |
| 49 | 5.0 | 0.032 | 0.048 | 0.22 | 0.009 | 4.9 | 0.032 | 0.048 | 0.21 | 0.009 |
| 50 | 5.1 | 0.033 | 0.049 | 0.22 | 0.009 | 5.0 | 0.033 | 0.050 | 0.22 | 0.009 |
| 51 | 5.2 | 0.033 | 0.052 | 0.22 | 0.010 | 5.1 | 0.034 | 0.052 | 0.23 | 0.009 |
| 52 | 5.3 | 0.034 | 0.055 | 0.23 | 0.010 | 5.3 | 0.035 | 0.055 | 0.23 | 0.009 |
| 53 | 5.4 | 0.035 | 0.058 | 0.23 | 0.010 | 5.5 | 0.036 | 0.062 | 0.24 | 0.011 |
| 54 | 5.6 | 0.036 | 0.064 | 0.24 | 0.011 | 5.8 | 0.038 | 0.070 | 0.25 | 0.012 |
| 55 | 5.8 | 0.038 | 0.070 | 0.25 | 0.012 | 6.2 | 0.042 | 0.081 | 0.27 | 0.014 |
| 56 | 6.1 | 0.041 | 0.078 | 0.26 | 0.014 | 6.5 | 0.044 | 0.088 | 0.28 | 0.015 |
| 57 | 6.4 | 0.043 | 0.086 | 0.28 | 0.015 | 6.9 | 0.047 | 0.097 | 0.30 | 0.017 |
| 58 | 6.8 | 0.046 | 0.095 | 0.29 | 0.017 | 7.2 | 0.049 | 0.103 | 0.32 | 0.018 |
| 59 | 7.1 | 0.049 | 0.101 | 0.31 | 0.018 | 7.6 | 0.052 | 0.112 | 0.34 | 0.020 |
| 60 | 7.5 | 0.052 | 0.110 | 0.33 | 0.020 | 8.0 | 0.056 | 0.119 | 0.36 | 0.022 |
| 61 | 7.9 | 0.055 | 0.117 | 0.35 | 0.021 | 8.4 | 0.058 | 0.127 | 0.38 | 0.023 |
| 62 | 8.2 | 0.057 | 0.123 | 0.37 | 0.023 | 8.7 | 0.061 | 0.132 | 0.40 | 0.025 |
| 63 | 8.6 | 0.060 | 0.130 | 0.40 | 0.024 | 9.1 | 0.064 | 0.139 | 0.43 | 0.026 |
| 64 | 9.0 | 0.063 | 0.137 | 0.42 | 0.026 | 9.5 | 0.067 | 0.145 | 0.45 | 0.028 |
| 65 | 9.4 | 0.066 | 0.143 | 0.45 | 0.027 | 9.9 | 0.069 | 0.151 | 0.48 | 0.029 |
| 66 | 9.8 | 0.069 | 0.150 | 0.48 | 0.029 | 10.3 | 0.072 | 0.157 | 0.52 | 0.031 |
| 67 | 10.1 | 0.071 | 0.154 | 0.50 | 0.030 | 10.8 | 0.076 | 0.165 | 0.59 | 0.033 |
| 68 | 10.6 | 0.074 | 0.162 | 0.56 | 0.032 | 11.2 | 0.079 | 0.171 | 0.63 | 0.034 |
| 69 | 11.0 | 0.077 | 0.168 | 0.61 | 0.033 | 11.6 | 0.081 | 0.176 | 0.68 | 0.036 |
| 70 | 11.4 | 0.080 | 0.173 | 0.66 | 0.035 | 12.0 | 0.084 | 0.182 | 0.73 | 0.037 |
| 71 | 11.8 | 0.083 | 0.179 | 0.71 | 0.036 | 12.5 | 0.087 | 0.188 | 0.79 | 0.039 |
| 72 | 12.2 | 0.085 | 0.184 | 0.75 | 0.038 | 12.9 | 0.090 | 0.194 | 0.83 | 0.040 |
| 73 | 12.7 | 0.089 | 0.191 | 0.81 | 0.039 | 13.4 | 0.093 | 0.200 | 0.89 | 0.042 |
| 74 | 13.1 | 0.091 | 0.194 | 0.85 | 0.041 | 13.9 | 0.097 | 0.206 | 0.94 | 0.044 |
| 75 | 13.6 | 0.095 | 0.203 | 0.91 | 0.042 | 14.3 | 0.099 | 0.211 | 0.98 | 0.045 |
| 76 | 14.0 | 0.097 | 0.207 | 0.95 | 0.044 | 14.8 | 0.102 | 0.217 | 1.03 | 0.047 |
| 77 | 14.5 | 0.100 | 0.214 | 1.00 | 0.046 | 15.3 | 0.105 | 0.223 | 1.09 | 0.048 |
| 78 | 15.0 | 0.104 | 0.220 | 1.06 | 0.047 | 15.8 | 0.109 | 0.229 | 1.14 | 0.050 |
| 79 | 15.4 | 0.106 | 0.224 | 1.10 | 0.049 | 16.3 | 0.112 | 0.235 | 1.19 | 0.051 |
| 80 | 15.9 | 0.109 | 0.230 | 1.15 | 0.050 | 16.8 | 0.115 | 0.241 | 1.24 | 0.053 |

TABLE 145—Continued

| | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Heart | Both kidneys | Liver | Spleen | Body weight | Heart | Both kidneys | Liver | Spleen |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 81 | 16.4 | 0.112 | 0.236 | 1.20 | 0.052 | 17.3 | 0.118 | 0.246 | 1.28 | 0.055 |
| 82 | 16.9 | 0.115 | 0.242 | 1.24 | 0.053 | 17.9 | 0.121 | 0.253 | 1.34 | 0.057 |
| 83 | 17.4 | 0.118 | 0.247 | 1.29 | 0.055 | 18.4 | 0.124 | 0.258 | 1.39 | 0.058 |
| 84 | 18.0 | 0.122 | 0.254 | 1.35 | 0.057 | 19.0 | 0.128 | 0.265 | 1.44 | 0.060 |
| 85 | 18.5 | 0.125 | 0.259 | 1.40 | 0.059 | 19.5 | 0.131 | 0.270 | 1.49 | 0.062 |
| 86 | 19.0 | 0.128 | 0.265 | 1.44 | 0.060 | 20.1 | 0.134 | 0.277 | 1.54 | 0.064 |
| 87 | 19.6 | 0.131 | 0.271 | 1.50 | 0.062 | 20.7 | 0.138 | 0.283 | 1.59 | 0.065 |
| 88 | 20.1 | 0.134 | 0.277 | 1.54 | 0.064 | 21.2 | 0.141 | 0.288 | 1.64 | 0.067 |
| 89 | 20.7 | 0.138 | 0.283 | 1.59 | 0.065 | 21.8 | 0.144 | 0.294 | 1.69 | 0.069 |
| 90 | 21.3 | 0.141 | 0.289 | 1.64 | 0.067 | 22.4 | 0.147 | 0.300 | 1.74 | 0.071 |
| 91 | 21.9 | 0.145 | 0.296 | 1.69 | 0.069 | 23.1 | 0.151 | 0.307 | 1.79 | 0.073 |
| 92 | 22.4 | 0.147 | 0.300 | 1.74 | 0.071 | 23.7 | 0.155 | 0.313 | 1.84 | 0.075 |
| 93 | 23.0 | 0.151 | 0.306 | 1.79 | 0.072 | 24.3 | 0.158 | 0.319 | 1.89 | 0.076 |
| 94 | 23.7 | 0.155 | 0.313 | 1.84 | 0.075 | 25.0 | 0.162 | 0.326 | 1.95 | 0.078 |
| 95 | 24.3 | 0.158 | 0.319 | 1.89 | 0.076 | 25.6 | 0.165 | 0.332 | 1.99 | 0.080 |
| 96 | 24.9 | 0.161 | 0.325 | 1.94 | 0.078 | 26.3 | 0.169 | 0.339 | 2.05 | 0.082 |
| 97 | 25.6 | 0.165 | 0.332 | 1.99 | 0.080 | 27.0 | 0.172 | 0.344 | 2.10 | 0.084 |
| 98 | 26.2 | 0.168 | 0.338 | 2.05 | 0.082 | 27.7 | 0.176 | 0.352 | 2.15 | 0.086 |
| 99 | 26.9 | 0.172 | 0.345 | 2.09 | 0.084 | 28.4 | 0.180 | 0.359 | 2.21 | 0.088 |
| 100 | 27.5 | 0.175 | 0.350 | 2.14 | 0.086 | 29.1 | 0.183 | 0.365 | 2.26 | 0.090 |
| 101 | 28.2 | 0.178 | 0.357 | 2.19 | 0.088 | 29.8 | 0.187 | 0.372 | 2.31 | 0.092 |
| 102 | 28.9 | 0.182 | 0.364 | 2.24 | 0.090 | 30.5 | 0.190 | 0.378 | 2.36 | 0.094 |
| 103 | 29.6 | 0.186 | 0.370 | 2.29 | 0.092 | 31.3 | 0.194 | 0.386 | 2.41 | 0.097 |
| 104 | 30.3 | 0.189 | 0.377 | 2.34 | 0.094 | 32.0 | 0.198 | 0.392 | 2.46 | 0.099 |
| 105 | 31.1 | 0.193 | 0.384 | 2.40 | 0.096 | 32.8 | 0.202 | 0.400 | 2.52 | 0.101 |
| 106 | 31.8 | 0.197 | 0.390 | 2.45 | 0.098 | 33.6 | 0.206 | 0.407 | 2.57 | 0.103 |
| 107 | 32.5 | 0.200 | 0.397 | 2.50 | 0.100 | 34.4 | 0.209 | 0.414 | 2.63 | 0.106 |
| 108 | 33.3 | 0.204 | 0.404 | 2.55 | 0.102 | 35.2 | 0.213 | 0.421 | 2.68 | 0.108 |
| 109 | 34.1 | 0.208 | 0.411 | 2.61 | 0.105 | 36.0 | 0.217 | 0.428 | 2.73 | 0.110 |
| 110 | 34.9 | 0.212 | 0.419 | 2.66 | 0.107 | 36.9 | 0.221 | 0.436 | 2.79 | 0.113 |
| 111 | 35.7 | 0.216 | 0.426 | 2.71 | 0.109 | 37.7 | 0.225 | 0.444 | 2.84 | 0.115 |
| 112 | 36.5 | 0.219 | 0.433 | 2.77 | 0.112 | 38.6 | 0.229 | 0.451 | 2.90 | 0.117 |
| 113 | 37.3 | 0.223 | 0.440 | 2.82 | 0.114 | 39.5 | 0.234 | 0.459 | 2.96 | 0.120 |
| 114 | 38.2 | 0.227 | 0.448 | 2.88 | 0.116 | 40.3 | 0.237 | 0.466 | 3.01 | 0.122 |
| 115 | 39.0 | 0.231 | 0.455 | 2.93 | 0.118 | 41.3 | 0.242 | 0.475 | 3.07 | 0.125 |
| 116 | 39.9 | 0.235 | 0.463 | 2.98 | 0.121 | 42.2 | 0.246 | 0.483 | 3.13 | 0.127 |
| 117 | 40.8 | 0.239 | 0.471 | 3.04 | 0.123 | 43.1 | 0.250 | 0.491 | 3.18 | 0.130 |

TABLE 145—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Heart | Both kidneys | Liver | Spleen | Body weight | Heart | Both kidneys | Liver | Spleen |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 118 | 41.6 | 0.243 | 0.478 | 3.09 | 0.126 | 44.1 | 0.254 | 0.499 | 3.24 | 0.133 |
| 119 | 42.6 | 0.248 | 0.486 | 3.15 | 0.128 | 45.0 | 0.258 | 0.507 | 3.29 | 0.135 |
| 120 | 43.5 | 0.252 | 0.494 | 3.20 | 0.131 | 46.0 | 0.263 | 0.515 | 3.35 | 0.138 |
| 121 | 44.4 | 0.256 | 0.502 | 3.26 | 0.133 | 47.0 | 0.267 | 0.524 | 3.41 | 0.141 |
| 122 | 45.4 | 0.260 | 0.510 | 3.32 | 0.136 | 48.0 | 0.272 | 0.532 | 3.47 | 0.143 |
| 123 | 46.3 | 0.264 | 0.518 | 3.37 | 0.139 | 49.1 | 0.276 | 0.542 | 3.53 | 0.146 |
| 124 | 47.3 | 0.269 | 0.526 | 3.43 | 0.141 | 50.1 | 0.281 | 0.550 | 3.59 | 0.149 |
| 125 | 48.3 | 0.273 | 0.535 | 3.49 | 0.144 | 51.2 | 0.285 | 0.559 | 3.65 | 0.152 |
| 126 | 49.3 | 0.277 | 0.543 | 3.54 | 0.147 | 52.3 | 0.290 | 0.568 | 3.71 | 0.155 |
| 127 | 50.4 | 0.282 | 0.553 | 3.61 | 0.150 | 53.4 | 0.295 | 0.578 | 3.77 | 0.158 |
| 128 | 51.4 | 0.286 | 0.561 | 3.66 | 0.152 | 54.5 | 0.299 | 0.587 | 3.83 | 0.161 |
| 129 | 52.5 | 0.291 | 0.570 | 3.72 | 0.155 | 55.6 | 0.304 | 0.596 | 3.89 | 0.164 |
| 130 | 53.6 | 0.295 | 0.579 | 3.78 | 0.158 | 56.8 | 0.309 | 0.606 | 3.96 | 0.167 |
| 131 | 54.7 | 0.300 | 0.588 | 3.84 | 0.161 | 58.0 | 0.314 | 0.616 | 4.02 | 0.170 |
| 132 | 55.8 | 0.305 | 0.598 | 3.90 | 0.164 | 59.2 | 0.319 | 0.626 | 4.09 | 0.173 |
| 133 | 56.9 | 0.309 | 0.607 | 3.96 | 0.167 | 60.4 | 0.324 | 0.635 | 4.15 | 0.177 |
| 134 | 58.1 | 0.314 | 0.617 | 4.03 | 0.171 | 61.6 | 0.328 | 0.645 | 4.21 | 0.180 |
| 135 | 59.3 | 0.319 | 0.626 | 4.09 | 0.174 | 62.9 | 0.334 | 0.656 | 4.28 | 0.183 |
| 136 | 60.5 | 0.324 | 0.636 | 4.15 | 0.177 | 64.2 | 0.339 | 0.666 | 4.35 | 0.187 |
| 137 | 61.7 | 0.329 | 0.646 | 4.22 | 0.180 | 65.5 | 0.344 | 0.677 | 4.41 | 0.190 |
| 138 | 62.9 | 0.334 | 0.656 | 4.28 | 0.183 | 66.8 | 0.349 | 0.687 | 4.48 | 0.194 |
| 139 | 64.1 | 0.338 | 0.666 | 4.34 | 0.186 | 68.1 | 0.354 | 0.698 | 4.54 | 0.197 |
| 140 | 65.4 | 0.344 | 0.676 | 4.41 | 0.190 | 69.5 | 0.360 | 0.709 | 4.61 | 0.201 |
| 141 | 66.7 | 0.349 | 0.687 | 4.47 | 0.193 | 70.9 | 0.365 | 0.720 | 4.68 | 0.204 |
| 142 | 68.0 | 0.354 | 0.697 | 4.54 | 0.197 | 72.3 | 0.370 | 0.732 | 4.75 | 0.208 |
| 143 | 69.3 | 0.359 | 0.708 | 4.60 | 0.200 | 73.7 | 0.376 | 0.743 | 4.82 | 0.212 |
| 144 | 70.7 | 0.364 | 0.719 | 4.67 | 0.204 | 75.2 | 0.382 | 0.755 | 4.89 | 0.216 |
| 145 | 72.1 | 0.370 | 0.730 | 4.74 | 0.208 | 76.7 | 0.387 | 0.767 | 4.97 | 0.220 |
| 146 | 73.5 | 0.375 | 0.741 | 4.81 | 0.211 | 78.2 | 0.393 | 0.779 | 5.04 | 0.224 |
| 147 | 74.9 | 0.380 | 0.752 | 4.88 | 0.215 | 79.7 | 0.399 | 0.791 | 5.11 | 0.228 |
| 148 | 76.3 | 0.386 | 0.764 | 4.95 | 0.219 | 81.3 | 0.405 | 0.803 | 5.19 | 0.232 |
| 149 | 77.8 | 0.391 | 0.775 | 5.02 | 0.223 | 82.8 | 0.410 | 0.815 | 5.26 | 0.236 |
| 150 | 79.3 | 0.397 | 0.787 | 5.09 | 0.227 | 84.4 | 0.416 | 0.828 | 5.33 | 0.240 |
| 151 | 80.8 | 0.403 | 0.799 | 5.16 | 0.230 | 86.1 | 0.422 | 0.841 | 5.41 | 0.244 |
| 152 | 82.4 | 0.409 | 0.812 | 5.24 | 0.235 | 87.7 | 0.428 | 0.854 | 5.48 | 0.248 |
| 153 | 83.9 | 0.414 | 0.824 | 5.31 | 0.239 | 89.4 | 0.435 | 0.867 | 5.56 | 0.253 |

TABLE 145—Continued

| | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Heart | Both kidneys | Liver | Spleen | Body weight | Heart | Both kidneys | Liver | Spleen |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 154 | 85.5 | 0.420 | 0.836 | 5.38 | 0.243 | 91.1 | 0.441 | 0.880 | 5.64 | 0.257 |
| 155 | 87.1 | 0.426 | 0.849 | 5.46 | 0.247 | 92.9 | 0.447 | 0.894 | 5.72 | 0.262 |
| 156 | 88.7 | 0.432 | 0.862 | 5.53 | 0.251 | 94.6 | 0.453 | 0.908 | 5.80 | 0.266 |
| 157 | 90.4 | 0.438 | 0.875 | 5.61 | 0.255 | 96.4 | 0.460 | 0.922 | 5.88 | 0.271 |
| 158 | 92.1 | 0.444 | 0.888 | 5.68 | 0.260 | 98.3 | 0.467 | 0.937 | 5.96 | 0.276 |
| 159 | 93.8 | 0.450 | 0.901 | 5.76 | 0.264 | 100.1 | 0.473 | 0.951 | 6.04 | 0.281 |
| 160 | 95.6 | 0.457 | 0.916 | 5.84 | 0.269 | 102.0 | 0.480 | 0.965 | 6.12 | 0.285 |
| 161 | 97.3 | 0.463 | 0.929 | 5.92 | 0.273 | 103.9 | 0.486 | 0.980 | 6.21 | 0.290 |
| 162 | 99.2 | 0.470 | 0.944 | 6.00 | 0.278 | 105.9 | 0.493 | 0.996 | 6.29 | 0.295 |
| 163 | 101.0 | 0.476 | 0.958 | 6.08 | 0.283 | 107.9 | 0.500 | 1.011 | 6.38 | 0.301 |
| 164 | 102.8 | 0.483 | 0.971 | 6.16 | 0.287 | 109.9 | 0.507 | 1.026 | 6.47 | 0.306 |
| 165 | 104.7 | 0.489 | 0.986 | 6.24 | 0.292 | 111.9 | 0.514 | 1.042 | 6.55 | 0.311 |
| 166 | 106.7 | 0.496 | 1.002 | 6.33 | 0.298 | 114.0 | 0.522 | 1.058 | 6.64 | 0.316 |
| 167 | 108.6 | 0.502 | 1.016 | 6.41 | 0.302 | 116.1 | 0.529 | 1.074 | 6.73 | 0.322 |
| 168 | 110.6 | 0.510 | 1.032 | 6.50 | 0.308 | 118.3 | 0.536 | 1.091 | 6.82 | 0.327 |
| 169 | 112.6 | 0.517 | 1.047 | 6.58 | 0.313 | 120.5 | 0.544 | 1.108 | 6.92 | 0.333 |
| 170 | 114.7 | 0.524 | 1.063 | 6.67 | 0.318 | 122.7 | 0.551 | 1.125 | 7.01 | 0.339 |
| 171 | 116.7 | 0.531 | 1.079 | 6.76 | 0.323 | 125.0 | 0.559 | 1.142 | 7.10 | 0.344 |
| 172 | 118.9 | 0.538 | 1.096 | 6.85 | 0.329 | 127.3 | 0.567 | 1.160 | 7.20 | 0.350 |
| 173 | 121.0 | 0.545 | 1.112 | 6.94 | 0.334 | 129.6 | 0.575 | 1.178 | 7.29 | 0.356 |
| 174 | 123.2 | 0.553 | 1.129 | 7.03 | 0.340 | 132.0 | 0.583 | 1.196 | 7.39 | 0.362 |
| 175 | 125.4 | 0.560 | 1.145 | 7.12 | 0.345 | 134.4 | 0.591 | 1.214 | 7.49 | 0.368 |
| 176 | 127.7 | 0.568 | 1.163 | 7.22 | 0.351 | 136.8 | 0.599 | 1.232 | 7.59 | 0.375 |
| 177 | 130.0 | 0.576 | 1.181 | 7.31 | 0.357 | 139.3 | 0.607 | 1.251 | 7.69 | 0.381 |
| 178 | 132.3 | 0.584 | 1.198 | 7.40 | 0.363 | 141.9 | 0.615 | 1.271 | 7.79 | 0.387 |
| 179 | 134.6 | 0.591 | 1.216 | 7.50 | 0.369 | 144.4 | 0.624 | 1.290 | 7.89 | 0.394 |
| 180 | 137.0 | 0.599 | 1.234 | 7.60 | 0.375 | 147.1 | 0.632 | 1.311 | 8.00 | 0.401 |
| 181 | 139.5 | 0.607 | 1.253 | 7.70 | 0.381 | 149.7 | 0.641 | 1.330 | 8.10 | 0.407 |
| 182 | 142.0 | 0.616 | 1.272 | 7.80 | 0.388 | 152.4 | 0.650 | 1.351 | 8.21 | 0.414 |
| 183 | 144.5 | 0.622 | 1.291 | 7.90 | 0.394 | 155.2 | 0.659 | 1.372 | 8.32 | 0.421 |
| 184 | 147.0 | 0.632 | 1.310 | 8.00 | 0.400 | 158.0 | 0.668 | 1.393 | 8.43 | 0.428 |
| 185 | 149.6 | 0.641 | 1.330 | 8.10 | 0.407 | 160.8 | 0.677 | 1.414 | 8.54 | 0.435 |
| 186 | 152.3 | 0.649 | 1.350 | 8.21 | 0.414 | 163.7 | 0.686 | 1.436 | 8.65 | 0.443 |
| 187 | 155.0 | 0.658 | 1.370 | 8.31 | 0.421 | 166.6 | 0.696 | 1.458 | 8.77 | 0.450 |
| 188 | 157.7 | 0.667 | 1.391 | 8.42 | 0.428 | 169.6 | 0.705 | 1.481 | 8.88 | 0.458 |
| 189 | 160.5 | 0.676 | 1.412 | 8.53 | 0.435 | 172.6 | 0.715 | 1.503 | 9.00 | 0.465 |
| 190 | 163.3 | 0.685 | 1.433 | 8.64 | 0.442 | 175.7 | 0.725 | 1.526 | 9.12 | 0.473 |

TABLE 145—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Heart | Both kidneys | Liver | Spleen | Body weight | Heart | Both kidneys | Liver | Spleen |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 191 | 166.2 | 0.694 | 1.455 | 8.75 | 0.449 | 178.8 | 0.734 | 1.550 | 9.23 | 0.481 |
| 192 | 169.1 | 0.704 | 1.477 | 8.86 | 0.456 | 182.0 | 0.744 | 1.574 | 9.36 | 0.489 |
| 193 | 172.0 | 0.713 | 1.499 | 8.98 | 0.464 | 185.2 | 0.755 | 1.598 | 9.48 | 0.497 |
| 194 | 175.0 | 0.722 | 1.521 | 9.09 | 0.471 | 188.5 | 0.765 | 1.622 | 9.60 | 0.505 |
| 195 | 178.1 | 0.732 | 1.544 | 9.21 | 0.479 | 191.9 | 0.776 | 1.648 | 9.73 | 0.514 |
| 196 | 181.2 | 0.742 | 1.568 | 9.33 | 0.487 | 195.3 | 0.786 | 1.673 | 9.86 | 0.522 |
| 197 | 184.3 | 0.752 | 1.591 | 9.45 | 0.495 | 198.7 | 0.797 | 1.699 | 9.99 | 0.531 |
| 198 | 187.5 | 0.762 | 1.615 | 9.57 | 0.503 | 202.2 | 0.808 | 1.725 | 10.12 | 0.540 |
| 199 | 190.8 | 0.772 | 1.640 | 9.69 | 0.511 | 205.8 | 0.819 | 1.752 | 10.25 | 0.549 |
| 200 | 194.1 | 0.782 | 1.664 | 9.82 | 0.519 | 209.4 | 0.830 | 1.779 | 10.39 | 0.558 |
| 201 | 197.4 | 0.793 | 1.689 | 9.94 | 0.528 | 213.1 | 0.841 | 1.806 | 10.52 | 0.567 |
| 202 | 200.8 | 0.803 | 1.714 | 10.07 | 0.536 | 216.8 | 0.853 | 1.834 | 10.66 | 0.577 |
| 203 | 204.3 | 0.814 | 1.740 | 10.20 | 0.545 | 220.7 | 0.865 | 1.863 | 10.80 | 0.586 |
| 204 | 207.8 | 0.825 | 1.767 | 10.33 | 0.554 | 224.5 | 0.876 | 1.891 | 10.94 | 0.596 |
| 205 | 211.4 | 0.836 | 1.793 | 10.46 | 0.563 | 228.4 | 0.888 | 1.920 | 11.09 | 0.606 |
| 206 | 215.0 | 0.847 | 1.820 | 10.59 | 0.572 | 232.4 | 0.900 | 1.950 | 11.23 | 0.616 |
| 207 | 218.7 | 0.859 | 1.848 | 10.73 | 0.581 | 236.5 | 0.913 | 1.980 | 11.38 | 0.626 |
| 208 | 222.5 | 0.870 | 1.876 | 10.87 | 0.591 | 240.6 | 0.925 | 2.011 | 11.53 | 0.636 |
| 209 | 226.3 | 0.882 | 1.904 | 11.01 | 0.600 | 244.8 | 0.938 | 2.042 | 11.68 | 0.647 |
| 210 | 230.2 | 0.894 | 1.933 | 11.15 | 0.610 | 249.1 | 0.951 | 2.074 | 11.84 | 0.657 |
| 211 | 234.1 | 0.905 | 1.962 | 11.29 | 0.620 | 253.4 | 0.964 | 2.106 | 11.99 | 0.668 |
| 212 | 238.1 | 0.918 | 1.992 | 11.44 | 0.630 | 257.8 | 0.977 | 2.138 | 12.15 | 0.679 |
| 213 | 242.2 | 0.930 | 2.023 | 11.59 | 0.640 | 262.3 | 0.990 | 2.171 | 12.31 | 0.691 |
| 214 | 246.3 | 0.942 | 2.053 | 11.74 | 0.650 | 266.9 | 1.004 | 2.205 | 12.47 | 0.702 |
| 215 | 250.5 | 0.955 | 2.084 | 11.89 | 0.661 | 271.5 | 1.018 | 2.239 | 12.64 | 0.713 |
| 216 | 254.7 | 0.968 | 2.115 | 12.04 | 0.671 | 276.2 | 1.032 | 2.274 | 12.80 | 0.725 |
| 217 | 259.1 | 0.981 | 2.148 | 12.20 | 0.683 | 281.0 | 1.046 | 2.310 | 12.97 | 0.737 |
| 218 | 263.5 | 0.994 | 2.180 | 12.35 | 0.694 | 285.8 | 1.060 | 2.345 | 13.14 | 0.749 |
| 219 | 267.9 | 1.007 | 2.213 | 12.50 | 0.704 | 290.8 | 1.075 | 2.382 | 13.32 | 0.762 |
| 220 | 272.5 | 1.021 | 2.247 | 12.67 | 0.716 | 295.8 | 1.090 | 2.419 | 13.50 | 0.774 |
| 221 | 277.1 | 1.034 | 2.281 | 12.84 | 0.727 | 300.9 | 1.105 | 2.457 | 13.67 | 0.787 |
| 222 | 281.8 | 1.048 | 2.316 | 13.00 | 0.739 | 306.1 | 1.120 | 2.495 | 13.86 | 0.800 |
| 223 | 286.5 | 1.062 | 2.350 | 13.17 | 0.751 | 311.3 | 1.135 | 2.533 | 14.04 | 0.813 |
| 224 | 291.4 | 1.077 | 2.386 | 13.34 | 0.763 | 316.7 | 1.151 | 2.573 | 14.23 | 0.826 |
| 225 | 296.3 | 1.091 | 2.423 | 13.51 | 0.775 | 322.1 | 1.167 | 2.613 | 14.41 | 0.840 |
| 226 | 301.3 | 1.106 | 2.460 | 13.69 | 0.788 | 327.7 | 1.183 | 2.654 | 14.61 | 0.854 |
| 227 | 306.4 | 1.121 | 2.497 | 13.87 | 0.801 | 333.3 | 1.200 | 2.695 | 14.80 | 0.868 |

TABLE 145—Concluded

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Heart | Both kidneys | Liver | Spleen | Body weight | Heart | Both kidneys | Liver | Spleen |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 228 | 311.5 | 1.136 | 2.535 | 14.05 | 0.813 | 339.0 | 1.216 | 2.737 | 15.00 | 0.882 |
| 229 | 316.8 | 1.152 | 2.574 | 14.23 | 0.826 | 344.8 | 1.233 | 2.780 | 15.20 | 0.896 |
| 230 | 322.1 | 1.167 | 2.613 | 14.41 | 0.840 | 350.7 | 1.250 | 2.823 | 15.40 | 0.911 |
| 231 | 327.5 | 1.183 | 2.652 | 14.60 | 0.853 | 356.7 | 1.268 | 2.867 | 15.61 | 0.926 |
| 232 | 333.0 | 1.199 | 2.693 | 14.79 | 0.867 | 362.8 | 1.285 | 2.912 | 15.82 | 0.941 |
| 233 | 338.6 | 1.215 | 2.734 | 14.99 | 0.881 | 369.0 | 1.303 | 2.957 | 16.03 | 0.956 |
| 234 | 344.3 | 1.232 | 2.776 | 15.18 | 0.895 | 375.3 | 1.321 | 3.004 | 16.24 | 0.972 |
| 235 | 350.0 | 1.248 | 2.818 | 15.38 | 0.909 | 381.7 | 1.340 | 3.050 | 16.46 | 0.988 |
| 236 | 355.9 | 1.265 | 2.861 | 15.58 | 0.924 | 388.2 | 1.358 | 3.098 | 16.68 | 1.004 |
| 237 | 361.9 | 1.283 | 2.905 | 15.79 | 0.939 | 394.9 | 1.377 | 3.147 | 16.91 | 1.021 |
| 238 | 367.9 | 1.300 | 2.949 | 15.99 | 0.954 | 401.6 | 1.397 | 3.196 | 17.14 | 1.037 |
| 239 | 374.1 | 1.318 | 2.995 | 16.20 | 0.969 | 408.4 | 1.416 | 3.246 | 17.37 | 1.054 |
| 240 | 380.3 | 1.336 | 3.040 | 16.42 | 0.984 | 415.4 | 1.436 | 3.297 | 17.61 | 1.072 |
| 241 | 386.6 | 1.354 | 3.086 | 16.63 | 1.000 | 422.4 | 1.456 | 3.349 | 17.84 | 1.089 |
| 242 | 393.1 | 1.372 | 3.134 | 16.85 | 1.016 | 429.6 | 1.477 | 3.401 | 18.08 | 1.107 |
| 243 | 399.6 | 1.391 | 3.182 | 17.07 | 1.032 | 436.9 | 1.497 | 3.455 | 18.33 | 1.125 |
| 244 | 406.3 | 1.410 | 3.231 | 17.30 | 1.049 | 444.3 | 1.518 | 3.509 | 18.58 | 1.143 |
| 245 | 413.1 | 1.429 | 3.280 | 17.53 | 1.066 | 451.9 | 1.540 | 3.564 | 18.83 | 1.162 |
| 246 | 419.9 | 1.449 | 3.330 | 17.76 | 1.083 | 459.5 | 1.561 | 3.620 | 19.09 | 1.181 |
| 247 | 426.9 | 1.469 | 3.381 | 17.98 | 1.100 | 467.3 | 1.583 | 3.677 | 19.35 | 1.200 |
| 248 | 434.0 | 1.489 | 3.433 | 18.23 | 1.118 | 475.2 | 1.606 | 3.734 | 19.61 | 1.220 |
| 249 | 441.2 | 1.509 | 3.486 | 18.47 | 1.136 | 483.3 | 1.628 | 3.794 | 19.88 | 1.240 |
| 250 | 448.5 | 1.530 | 3.539 | 18.72 | 1.154 | 491.5 | 1.652 | 3.853 | 20.15 | 1.260 |

TABLE 146

*Giving for each sex the weights of body, lungs, blood, alimentary tract and gonads (testes and ovaries) for each millimeter of body length. See Charts 36, 37, 38, 45 and 46*

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Lungs | Blood | Alimen. tract | Testes | Body weight | Lungs | Blood | Alimen. tract | Ovaries |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 47 | 4.9 | 0.078 | 0.44 | 0.14 | 0.004 | 4.7 | 0.078 | 0.41 | 0.14 | 0.0006 |
| 48 | 4.9 | 0.079 | 0.44 | 0.14 | 0.004 | 4.7 | 0.079 | 0.41 | 0.14 | 0.0006 |
| 49 | 5.0 | 0.080 | 0.45 | 0.15 | 0.004 | 4.9 | 0.080 | 0.43 | 0.15 | 0.0008 |
| 50 | 5.1 | 0.081 | 0.45 | 0.15 | 0.004 | 5.0 | 0.081 | 0.44 | 0.15 | 0.0009 |
| 51 | 5.2 | 0.082 | 0.46 | 0.15 | 0.004 | 5.1 | 0.082 | 0.45 | 0.15 | 0.0009 |
| 52 | 5.3 | 0.083 | 0.47 | 0.16 | 0.006 | 5.3 | 0.084 | 0.47 | 0.16 | 0.0010 |
| 53 | 5.4 | 0.085 | 0.48 | 0.16 | 0.006 | 5.5 | 0.086 | 0.49 | 0.16 | 0.0011 |
| 54 | 5.6 | 0.087 | 0.50 | 0.17 | 0.007 | 5.8 | 0.090 | 0.51 | 0.18 | 0.0013 |
| 55 | 5.8 | 0.090 | 0.51 | 0.18 | 0.007 | 6.2 | 0.094 | 0.54 | 0.19 | 0.0015 |
| 56 | 6.1 | 0.093 | 0.53 | 0.19 | 0.009 | 6.5 | 0.097 | 0.56 | 0.20 | 0.0016 |
| 57 | 6.4 | 0.096 | 0.56 | 0.20 | 0.011 | 6.9 | 0.102 | 0.60 | 0.22 | 0.0019 |
| 58 | 6.8 | 0.101 | 0.59 | 0.21 | 0.013 | 7.2 | 0.105 | 0.62 | 0.23 | 0.0020 |
| 59 | 7.1 | 0.104 | 0.61 | 0.22 | 0.016 | 7.6 | 0.109 | 0.65 | 0.24 | 0.0022 |
| 60 | 7.5 | 0.108 | 0.64 | 0.24 | 0.019 | 8.0 | 0.113 | 0.68 | 0.25 | 0.0024 |
| 61 | 7.9 | 0.112 | 0.67 | 0.25 | 0.023 | 8.4 | 0.117 | 0.71 | 0.27 | 0.0025 |
| 62 | 8.2 | 0.115 | 0.69 | 0.26 | 0.026 | 8.7 | 0.120 | 0.73 | 0.27 | 0.0026 |
| 63 | 8.6 | 0.119 | 0.73 | 0.27 | 0.031 | 9.1 | 0.124 | 0.76 | 0.28 | 0.0028 |
| 64 | 9.0 | 0.123 | 0.76 | 0.28 | 0.036 | 9.5 | 0.128 | 0.79 | 0.30 | 0.0029 |
| 65 | 9.4 | 0.127 | 0.79 | 0.29 | 0.041 | 9.9 | 0.131 | 0.82 | 0.31 | 0.0031 |
| 66 | 9.8 | 0.130 | 0.82 | 0.30 | 0.047 | 10.3 | 0.135 | 0.85 | 0.34 | 0.0032 |
| 67 | 10.1 | 0.133 | 0.84 | 0.31 | 0.050 | 10.8 | 0.139 | 0.89 | 0.41 | 0.0034 |
| 68 | 10.6 | 0.138 | 0.88 | 0.39 | 0.051 | 11.2 | 0.143 | 0.92 | 0.47 | 0.0035 |
| 69 | 11.0 | 0.141 | 0.91 | 0.44 | 0.052 | 11.6 | 0.146 | 0.95 | 0.52 | 0.0036 |
| 70 | 11.4 | 0.145 | 0.93 | 0.50 | 0.053 | 12.0 | 0.150 | 0.98 | 0.58 | 0.0037 |
| 71 | 11.8 | 0.148 | 0.96 | 0.55 | 0.054 | 12.5 | 0.154 | 1.02 | 0.64 | 0.0039 |
| 72 | 12.2 | 0.152 | 0.99 | 0.60 | 0.055 | 12.9 | 0.157 | 1.04 | 0.69 | 0.0040 |
| 73 | 12.7 | 0.155 | 1.03 | 0.67 | 0.057 | 13.4 | 0.161 | 1.08 | 0.76 | 0.0041 |
| 74 | 13.1 | 0.159 | 1.06 | 0.72 | 0.058 | 13.9 | 0.165 | 1.12 | 0.82 | 0.0042 |
| 75 | 13.6 | 0.163 | 1.10 | 0.78 | 0.060 | 14.3 | 0.169 | 1.13 | 0.87 | 0.0043 |
| 76 | 14.0 | 0.166 | 1.12 | 0.83 | 0.061 | 14.8 | 0.173 | 1.18 | 0.93 | 0.0044 |
| 77 | 14.5 | 0.170 | 1.16 | 0.89 | 0.063 | 15.3 | 0.177 | 1.22 | 0.99 | 0.0046 |
| 78 | 15.0 | 0.174 | 1.20 | 0.95 | 0.065 | 15.8 | 0.180 | 1.25 | 1.04 | 0.0047 |
| 79 | 15.4 | 0.177 | 1.23 | 1.00 | 0.067 | 16.3 | 0.184 | 1.29 | 1.10 | 0.0048 |
| 80 | 15.9 | 0.181 | 1.26 | 1.05 | 0.069 | 16.8 | 0.188 | 1.33 | 1.16 | 0.0049 |

TABLE 146—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Lungs | Blood | Alimen. tract | Testes | Body weight | Lungs | Blood | Alimen. tract | Ovaries |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 81 | 16.4 | 0.185 | 1.30 | 1.11 | 0.071 | 17.3 | 0.192 | 1.36 | 1.21 | 0.0050 |
| 82 | 16.9 | 0.189 | 1.33 | 1.17 | 0.073 | 17.9 | 0.196 | 1.40 | 1.28 | 0.0051 |
| 83 | 17.4 | 0.193 | 1.37 | 1.22 | 0.076 | 18.4 | 0.200 | 1.44 | 1.33 | 0.0052 |
| 84 | 18.0 | 0.197 | 1.41 | 1.29 | 0.078 | 19.0 | 0.204 | 1.48 | 1.39 | 0.0053 |
| 85 | 18.5 | 0.201 | 1.45 | 1.34 | 0.081 | 19.5 | 0.208 | 1.52 | 1.44 | 0.0054 |
| 86 | 19.0 | 0.204 | 1.48 | 1.39 | 0.084 | 20.1 | 0.212 | 1.56 | 1.50 | 0.0055 |
| 87 | 19.6 | 0.209 | 1.52 | 1.45 | 0.087 | 20.7 | 0.216 | 1.60 | 1.56 | 0.0056 |
| 88 | 20.1 | 0.212 | 1.56 | 1.50 | 0.089 | 21.2 | 0.220 | 1.63 | 1.61 | 0.0057 |
| 89 | 20.7 | 0.216 | 1.60 | 1.56 | 0.093 | 21.8 | 0.224 | 1.68 | 1.67 | 0.0058 |
| 90 | 21.3 | 0.221 | 1.64 | 1.62 | 0.096 | 22.4 | 0.228 | 1.72 | 1.73 | 0.0058 |
| 91 | 21.9 | 0.225 | 1.68 | 1.68 | 0.100 | 23.1 | 0.233 | 1.76 | 1.79 | 0.0059 |
| 92 | 22.4 | 0.228 | 1.72 | 1.73 | 0.103 | 23.7 | 0.237 | 1.81 | 1.85 | 0.0060 |
| 93 | 23.0 | 0.232 | 1.76 | 1.78 | 0.107 | 24.3 | 0.241 | 1.85 | 1.90 | 0.0061 |
| 94 | 23.7 | 0.237 | 1.81 | 1.85 | 0.112 | 25.0 | 0.246 | 1.90 | 1.96 | 0.0062 |
| 95 | 24.3 | 0.241 | 1.85 | 1.90 | 0.116 | 25.6 | 0.250 | 1.94 | 2.02 | 0.0063 |
| 96 | 24.9 | 0.245 | 1.89 | 1.96 | 0.120 | 26.3 | 0.254 | 1.98 | 2.08 | 0.0064 |
| 97 | 25.6 | 0.250 | 1.94 | 2.02 | 0.125 | 27.0 | 0.259 | 2.03 | 2.14 | 0.0065 |
| 98 | 26.2 | 0.254 | 1.98 | 2.07 | 0.130 | 27.7 | 0.264 | 2.08 | 2.20 | 0.0066 |
| 99 | 26.9 | 0.258 | 2.02 | 2.13 | 0.135 | 28.4 | 0.268 | 2.13 | 2.25 | 0.0067 |
| 100 | 27.5 | 0.262 | 2.06 | 2.18 | 0.140 | 29.1 | 0.273 | 2.17 | 2.31 | 0.0067 |
| 101 | 28.2 | 0.267 | 2.11 | 2.24 | 0.145 | 29.8 | 0.277 | 2.22 | 2.37 | 0.0068 |
| 102 | 28.9 | 0.271 | 2.16 | 2.30 | 0.151 | 30.5 | 0.282 | 2.27 | 2.42 | 0.0069 |
| 103 | 29.6 | 0.276 | 2.21 | 2.35 | 0.157 | 31.3 | 0.287 | 2.32 | 2.49 | 0.0070 |
| 104 | 30.3 | 0.280 | 2.25 | 2.41 | 0.163 | 32.0 | 0.291 | 2.37 | 2.54 | 0.0071 |
| 105 | 31.1 | 0.285 | 2.31 | 2.47 | 0.171 | 32.8 | 0.296 | 2.42 | 2.60 | 0.0071 |
| 106 | 31.8 | 0.290 | 2.35 | 2.53 | 0.177 | 33.6 | 0.301 | 2.47 | 2.66 | 0.0072 |
| 107 | 32.5 | 0.294 | 2.40 | 2.58 | 0.184 | 34.4 | 0.306 | 2.53 | 2.72 | 0.0073 |
| 108 | 33.3 | 0.299 | 2.45 | 2.64 | 0.192 | 35.2 | 0.311 | 2.58 | 2.78 | 0.0074 |
| 109 | 34.1 | 0.304 | 2.51 | 2.70 | 0.200 | 36.0 | 0.316 | 2.63 | 2.84 | 0.0075 |
| 110 | 34.9 | 0.309 | 2.56 | 2.76 | 0.208 | 36.9 | 0.321 | 2.69 | 2.90 | 0.0075 |
| 111 | 35.7 | 0.314 | 2.61 | 2.82 | 0.216 | 37.7 | 0.326 | 2.74 | 2.96 | 0.0076 |
| 112 | 36.5 | 0.319 | 2.66 | 2.88 | 0.225 | 38.6 | 0.332 | 2.80 | 3.02 | 0.0077 |
| 113 | 37.3 | 0.324 | 2.72 | 2.93 | 0.234 | 39.5 | 0.337 | 2.86 | 3.09 | 0.0078 |
| 114 | 38.2 | 0.329 | 2.78 | 3.00 | 0.244 | 40.3 | 0.342 | 2.91 | 3.14 | 0.0078 |
| 115 | 39.0 | 0.334 | 2.83 | 3.05 | 0.253 | 41.3 | 0.348 | 2.98 | 3.21 | 0.0079 |
| 116 | 39.9 | 0.339 | 2.89 | 3.11 | 0.264 | 42.2 | 0.353 | 3.04 | 3.27 | 0.0080 |
| 117 | 40.8 | 0.345 | 2.95 | 3.17 | 0.275 | 43.1 | 0.358 | 3.09 | 3.33 | 0.0081 |

TABLE 146—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Lungs | Blood | Alimen. tract | Testes | Body weight | Lungs | Blood | Alimen. tract | Ovaries |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 118 | 41.6 | 0.349 | 3.00 | 3.23 | 0.285 | 44.1 | 0.364 | 3.16 | 3.39 | 0.0081 |
| 119 | 42.6 | 0.355 | 3.06 | 3.29 | 0.298 | 45.0 | 0.369 | 3.22 | 3.45 | 0.0082 |
| 120 | 43.5 | 0.361 | 3.12 | 3.35 | 0.309 | 46.0 | 0.375 | 3.28 | 3.51 | 0.0083 |
| 121 | 44.4 | 0.366 | 3.18 | 3.41 | 0.321 | 47.0 | 0.381 | 3.35 | 3.58 | 0.0084 |
| 122 | 45.4 | 0.372 | 3.24 | 3.47 | 0.335 | 48.0 | 0.387 | 3.41 | 3.64 | 0.0084 |
| 123 | 46.3 | 0.377 | 3.30 | 3.53 | 0.348 | 49.1 | 0.393 | 3.48 | 3.71 | 0.0085 |
| 124 | 47.3 | 0.383 | 3.36 | 3.59 | 0.362 | 50.1 | 0.399 | 3.54 | 3.77 | 0.0086 |
| 125 | 48.3 | 0.389 | 3.43 | 3.66 | 0.377 | 51.2 | 0.405 | 3.61 | 3.83 | 0.0086 |
| 126 | 49.3 | 0.394 | 3.49 | 3.72 | 0.392 | 52.3 | 0.411 | 3.68 | 3.90 | 0.0087 |
| 127 | 50.4 | 0.401 | 3.56 | 3.78 | 0.408 | 53.4 | 0.418 | 3.75 | 3.96 | 0.0088 |
| 128 | 51.4 | 0.406 | 3.63 | 3.84 | 0.424 | 54.5 | 0.424 | 3.82 | 4.03 | 0.0089 |
| 129 | 52.5 | 0.413 | 3.69 | 3.91 | 0.442 | 55.6 | 0.430 | 3.89 | 4.09 | 0.0089 |
| 130 | 53.6 | 0.419 | 3.76 | 3.97 | 0.460 | 56.8 | 0.437 | 3.97 | 4.15 | 0.0090 |
| 131 | 54.7 | 0.425 | 3.83 | 4.04 | 0.478 | 58.0 | 0.444 | 4.04 | 4.22 | 0.0091 |
| 132 | 55.8 | 0.431 | 3.90 | 4.10 | 0.497 | 59.2 | 0.450 | 4.12 | 4.29 | 0.0091 |
| 133 | 56.9 | 0.437 | 3.97 | 4.16 | 0.516 | 60.4 | 0.457 | 4.19 | 4.36 | 0.0092 |
| 134 | 58.1 | 0.444 | 4.05 | 4.23 | 0.537 | 61.6 | 0.464 | 4.27 | 4.42 | 0.0093 |
| 135 | 59.3 | 0.451 | 4.12 | 4.30 | 0.559 | 62.9 | 0.471 | 4.35 | 4.49 | 0.0093 |
| 136 | 60.5 | 0.458 | 4.20 | 4.36 | 0.581 | 64.2 | 0.478 | 4.43 | 4.56 | 0.0094 |
| 137 | 61.7 | 0.464 | 4.27 | 4.43 | 0.604 | 65.5 | 0.485 | 4.51 | 4.63 | 0.0095 |
| 138 | 62.9 | 0.471 | 4.35 | 4.49 | 0.627 | 66.8 | 0.492 | 4.59 | 4.70 | 0.0099 |
| 139 | 64.1 | 0.477 | 4.42 | 4.56 | 0.651 | 68.1 | 0.499 | 4.67 | 4.77 | 0.0102 |
| 140 | 65.4 | 0.485 | 4.50 | 4.63 | 0.677 | 69.5 | 0.507 | 4.76 | 4.84 | 0.0106 |
| 141 | 66.7 | 0.492 | 4.58 | 4.70 | 0.704 | 70.9 | 0.515 | 4.84 | 4.91 | 0.0110 |
| 142 | 68.0 | 0.499 | 4.66 | 4.76 | 0.731 | 72.3 | 0.522 | 4.93 | 4.98 | 0.0115 |
| 143 | 69.3 | 0.506 | 4.74 | 4.83 | 0.759 | 73.7 | 0.530 | 5.01 | 5.05 | 0.0120 |
| 144 | 70.7 | 0.514 | 4.83 | 4.90 | 0.790 | 75.2 | 0.538 | 5.11 | 5.13 | 0.0126 |
| 145 | 72.1 | 0.521 | 4.92 | 4.97 | 0.821 | 76.7 | 0.546 | 5.20 | 5.20 | 0.0132 |
| 146 | 73.5 | 0.529 | 5.00 | 5.04 | 0.853 | 78.2 | 0.554 | 5.29 | 5.27 | 0.0139 |
| 147 | 74.9 | 0.536 | 5.09 | 5.11 | 0.885 | 79.7 | 0.562 | 5.38 | 5.35 | 0.0147 |
| 148 | 76.3 | 0.544 | 5.17 | 5.18 | 0.918 | 81.3 | 0.571 | 5.48 | 5.42 | 0.0155 |
| 149 | 77.8 | 0.552 | 5.27 | 5.26 | 0.955 | 82.8 | 0.579 | 5.57 | 5.50 | 0.0164 |
| 150 | 79.3 | 0.560 | 5.36 | 5.34 | 0.991 | 84.4 | 0.587 | 5.67 | 5.57 | 0.0173 |
| 151 | 80.8 | 0.568 | 5.45 | 5.40 | 1.031 | 86.1 | 0.596 | 5.77 | 5.65 | 0.0184 |
| 152 | 82.4 | 0.577 | 5.54 | 5.48 | 1.055 | 87.7 | 0.605 | 5.86 | 5.72 | 0.0195 |
| 153 | 83.9 | 0.585 | 5.64 | 5.55 | 1.078 | 89.4 | 0.614 | 5.97 | 5.80 | 0.0207 |

TABLE 146—Continued

| | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Lungs | Blood | Alimen. tract | Testes | Body weight | Lungs | Blood | Alimen. tract | Ovaries |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 154 | 85.5 | 0.593 | 5.73 | 5.63 | 1.102 | 91.1 | 0.623 | 6.07 | 5.88 | 0.0219 |
| 155 | 87.1 | 0.602 | 5.83 | 5.70 | 1.125 | 92.9 | 0.632 | 6.18 | 5.96 | 0.0233 |
| 156 | 88.7 | 0.610 | 5.92 | 5.77 | 1.148 | 94.6 | 0.641 | 6.28 | 6.04 | 0.0247 |
| 157 | 90.4 | 0.619 | 6.03 | 5.85 | 1.173 | 96.4 | 0.651 | 6.39 | 6.12 | 0.0262 |
| 158 | 92.1 | 0.628 | 6.13 | 5.93 | 1.196 | 98.3 | 0.661 | 6.50 | 6.20 | 0.0279 |
| 159 | 93.8 | 0.637 | 6.23 | 6.00 | 1.219 | 100.1 | 0.670 | 6.61 | 6.28 | 0.0296 |
| 160 | 95.6 | 0.646 | 6.34 | 6.08 | 1.243 | 102.0 | 0.680 | 6.72 | 6.46 | 0.0314 |
| 161 | 97.3 | 0.655 | 6.44 | 6.16 | 1.265 | 103.9 | 0.690 | 6.83 | 6.44 | 0.0334 |
| 162 | 99.2 | 0.665 | 6.55 | 6.24 | 1.290 | 105.9 | 0.700 | 6.95 | 6.53 | 0.0344 |
| 163 | 101.0 | 0.675 | 6.66 | 6.32 | 1.313 | 107.9 | 0.711 | 7.07 | 6.62 | 0.0377 |
| 164 | 102.8 | 0.684 | 6.77 | 6.40 | 1.335 | 109.9 | 0.721 | 7.18 | 6.70 | 0.0400 |
| 165 | 104.7 | 0.694 | 6.88 | 6.48 | 1.358 | 111.9 | 0.731 | 7.30 | 6.78 | 0.0411 |
| 166 | 106.7 | 0.704 | 7.00 | 6.56 | 1.382 | 114.0 | 0.742 | 7.43 | 6.87 | 0.0419 |
| 167 | 108.6 | 0.714 | 7.11 | 6.65 | 1.404 | 116.1 | 0.753 | 7.55 | 6.96 | 0.0425 |
| 168 | 110.6 | 0.725 | 7.23 | 6.73 | 1.428 | 118.3 | 0.764 | 7.68 | 7.05 | 0.0431 |
| 169 | 112.6 | 0.735 | 7.34 | 6.81 | 1.450 | 120.5 | 0.776 | 7.81 | 7.14 | 0.0435 |
| 170 | 114.7 | 0.746 | 7.47 | 6.90 | 1.473 | 122.7 | 0.787 | 7.93 | 7.23 | 0.0439 |
| 171 | 116.7 | 0.756 | 7.58 | 6.98 | 1.495 | 125.0 | 0.799 | 8.07 | 7.32 | 0.0443 |
| 172 | 118.9 | 0.768 | 7.71 | 7.07 | 1.519 | 127.3 | 0.811 | 8.20 | 7.41 | 0.0446 |
| 173 | 121.0 | 0.778 | 7.83 | 7.16 | 1.541 | 129.6 | 0.822 | 8.33 | 7.50 | 0.0449 |
| 174 | 123.2 | 0.790 | 7.96 | 7.25 | 1.564 | 132.0 | 0.835 | 8.47 | 7.60 | 0.0452 |
| 175 | 125.4 | 0.801 | 8.09 | 7.33 | 1.586 | 134.4 | 0.847 | 8.61 | 7.69 | 0.0455 |
| 176 | 127.7 | 0.813 | 8.22 | 7.43 | 1.609 | 136.8 | 0.859 | 8.75 | 7.78 | 0.0457 |
| 177 | 130.0 | 0.824 | 8.36 | 7.52 | 1.632 | 139.3 | 0.872 | 8.89 | 7.88 | 0.0459 |
| 178 | 132.3 | 0.836 | 8.49 | 7.61 | 1.654 | 141.9 | 0.885 | 9.04 | 7.98 | 0.0462 |
| 179 | 134.6 | 0.848 | 8.62 | 7.70 | 1.675 | 144.4 | 0.898 | 9.19 | 8.07 | 0.0464 |
| 180 | 137.0 | 0.860 | 8.76 | 7.79 | 1.698 | 147.1 | 0.911 | 9.34 | 8.18 | 0.0466 |
| 181 | 139.5 | 0.873 | 8.90 | 7.89 | 1.721 | 149.7 | 0.925 | 9.49 | 8.28 | 0.0468 |
| 182 | 142.0 | 0.886 | 9.05 | 7.98 | 1.743 | 152.4 | 0.938 | 10.22 | 8.38 | 0.0469 |
| 183 | 144.5 | 0.898 | 9.19 | 8.08 | 1.765 | 155.2 | 0.952 | 10.39 | 8.48 | 0.0471 |
| 184 | 147.0 | 0.911 | 9.26 | 8.17 | 1.787 | 158.0 | 0.967 | 10.56 | 8.58 | 0.0473 |
| 185 | 149.6 | 0.924 | 9.33 | 8.27 | 1.809 | 160.8 | 0.981 | 10.73 | 8.69 | 0.0474 |
| 186 | 152.3 | 0.938 | 9.40 | 8.37 | 1.832 | 163.7 | 0.995 | 10.90 | 8.79 | 0.0476 |
| 187 | 155.0 | 0.951 | 9.50 | 8.47 | 1.854 | 166.6 | 1.010 | 11.07 | 8.90 | 0.0477 |
| 188 | 157.7 | 0.965 | 9.64 | 8.57 | 1.876 | 169.6 | 1.025 | 11.25 | 9.01 | 0.0479 |
| 189 | 160.5 | 0.979 | 9.80 | 8.68 | 1.898 | 172.6 | 1.040 | 11.43 | 9.12 | 0.0480 |
| 190 | 163.3 | 0.993 | 9.95 | 8.78 | 1.920 | 175.7 | 1.055 | 11.62 | 9.23 | 0.0482 |

TABLE 146—Continued

| MALES | | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Lungs | Blood | Alimen. tract | Testes | Body weight | Lungs | Blood | Alimen. tract | Ovaries |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 191 | 166.2 | 1.008 | 10.11 | 8.88 | 1.942 | 178.8 | 1.071 | 11.80 | 9.34 | 0.0483 |
| 192 | 169.1 | 1.022 | 10.27 | 8.99 | 1.964 | 182.0 | 1.087 | 11.99 | 9.45 | 0.0484 |
| 193 | 172.0 | 1.037 | 10.43 | 9.09 | 1.985 | 185.2 | 1.103 | 12.18 | 9.56 | 0.0485 |
| 194 | 175.0 | 1.052 | 10.59 | 9.20 | 2.007 | 188.5 | 1.119 | 12.38 | 9.68 | 0.0487 |
| 195 | 178.1 | 1.067 | 10.76 | 9.31 | 2.030 | 191.9 | 1.136 | 12.58 | 9.80 | 0.0488 |
| 196 | 181.2 | 1.083 | 10.93 | 9.42 | 2.051 | 195.3 | 1.153 | 12.78 | 9.92 | 0.0489 |
| 197 | 184.3 | 1.098 | 11.10 | 9.53 | 2.073 | 198.7 | 1.170 | 12.98 | 10.03 | 0.0490 |
| 198 | 187.5 | 1.114 | 11.27 | 9.64 | 2.094 | 202.2 | 1.188 | 13.18 | 10.15 | 0.0491 |
| 199 | 190.8 | 1.131 | 11.45 | 9.76 | 2.117 | 205.8 | 1.206 | 13.39 | 10.28 | 0.0492 |
| 200 | 194.1 | 1.147 | 11.63 | 9.87 | 2.138 | 209.4 | 1.223 | 13.61 | 10.40 | 0.0493 |
| 201 | 197.4 | 1.164 | 11.81 | 9.99 | 2.159 | 213.1 | 1.242 | 13.82 | 10.53 | 0.0494 |
| 202 | 200.8 | 1.181 | 11.99 | 10.11 | 2.181 | 216.8 | 1.260 | 14.04 | 10.65 | 0.0495 |
| 203 | 204.3 | 1.198 | 12.18 | 10.23 | 2.203 | 220.7 | 1.279 | 14.26 | 10.78 | 0.0496 |
| 204 | 207.8 | 1.215 | 12.36 | 10.35 | 2.224 | 224.5 | 1.298 | 14.48 | 10.91 | 0.0497 |
| 205 | 211.4 | 1.233 | 12.56 | 10.47 | 2.246 | 228.4 | 1.317 | 14.71 | 11.04 | 0.0498 |
| 206 | 215.0 | 1.251 | 12.75 | 10.59 | 2.267 | 232.4 | 1.337 | 14.94 | 11.17 | 0.0499 |
| 207 | 218.7 | 1.269 | 12.95 | 10.71 | 2.289 | 236.5 | 1.357 | 15.18 | 11.31 | 0.0500 |
| 208 | 222.5 | 1.288 | 13.15 | 10.84 | 2.311 | 240.6 | 1.378 | 15.42 | 11.44 | 0.0501 |
| 209 | 226.3 | 1.307 | 13.35 | 10.97 | 2.332 | 244.8 | 1.398 | 15.66 | 11.58 | 0.0502 |
| 210 | 230.2 | 1.326 | 13.46 | 11.10 | 2.354 | 249.1 | 1.419 | 15.90 | 11.72 | 0.0503 |
| 211 | 234.1 | 1.346 | 13.76 | 11.23 | 2.375 | 253.4 | 1.441 | 16.15 | 11.86 | 0.0504 |
| 212 | 238.1 | 1.365 | 13.98 | 11.36 | 2.397 | 257.8 | 1.462 | 16.41 | 12.00 | 0.0505 |
| 213 | 242.2 | 1.386 | 14.19 | 11.49 | 2.418 | 262.3 | 1.484 | 16.66 | 12.14 | 0.0506 |
| 214 | 246.3 | 1.406 | 14.41 | 11.63 | 2.439 | 266.9 | 1.507 | 16.92 | 12.29 | 0.0507 |
| 215 | 250.5 | 1.426 | 14.63 | 11.76 | 2.461 | 271.5 | 1.530 | 17.19 | 12.44 | 0.0508 |
| 216 | 254.7 | 1.447 | 14.85 | 11.90 | 2.482 | 276.2 | 1.553 | 17.45 | 12.59 | 0.0508 |
| 217 | 259.1 | 1.469 | 15.08 | 12.04 | 2.503 | 281.0 | 1.576 | 17.73 | 12.74 | 0.0509 |
| 218 | 263.5 | 1.490 | 15.31 | 12.18 | 2.525 | 285.8 | 1.600 | 18.00 | 12.89 | 0.0510 |
| 219 | 267.9 | 1.512 | 15.54 | 12.32 | 2.546 | 290.8 | 1.624 | 18.28 | 13.05 | 0.0511 |
| 220 | 272.5 | 1.534 | 15.78 | 12.47 | 2.567 | 295.8 | 1.648 | 18.57 | 13.21 | 0.0512 |
| 221 | 277.1 | 1.557 | 16.02 | 12.62 | 2.588 | 300.9 | 1.673 | 18.85 | 13.36 | 0.0512 |
| 222 | 281.8 | 1.580 | 16.26 | 12.77 | 2.609 | 306.1 | 1.705 | 19.15 | 13.53 | 0.0513 |
| 223 | 286.5 | 1.603 | 16.55 | 12.91 | 2.630 | 311.3 | 1.724 | 19.44 | 13.69 | 0.0514 |
| 224 | 291.4 | 1.627 | 16.76 | 13.07 | 2.652 | 316.7 | 1.751 | 19.74 | 13.85 | 0.0515 |
| 225 | 296.3 | 1.651 | 17.02 | 13.22 | 2.673 | 322.1 | 1.777 | 20.05 | 14.02 | 0.0516 |
| 226 | 301.3 | 1.675 | 17.27 | 13.38 | 2.694 | 327.7 | 1.804 | 20.36 | 14.19 | 0.0516 |
| 227 | 306.4 | 1.700 | 17.54 | 13.54 | 2.715 | 333.3 | 1.831 | 20.67 | 14.36 | 0.0517 |

TABLE 146—Concluded

| | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Lungs | Blood | Alimen. tract | Testes | Body weight | Lungs | Blood | Alimen. tract | Ovaries |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 228 | 311.5 | 1.725 | 17.80 | 13.74 | 2.736 | 339.0 | 1.859 | 20.99 | 14.54 | 0.0518 |
| 229 | 316.8 | 1.751 | 18.07 | 13.86 | 2.757 | 344.8 | 1.887 | 21.31 | 14.71 | 0.0519 |
| 230 | 322.1 | 1.777 | 18.34 | 14.02 | 2.778 | 350.7 | 1.916 | 21.64 | 14.89 | 0.0519 |
| 231 | 327.5 | 1.803 | 18.62 | 14.19 | 2.799 | 356.7 | 1.945 | 21.97 | 15.07 | 0.0520 |
| 232 | 333.0 | 1.830 | 18.90 | 14.35 | 2.820 | 362.8 | 1.975 | 22.31 | 15.26 | 0.0521 |
| 233 | 338.6 | 1.857 | 19.19 | 14.52 | 2.841 | 369.0 | 2.005 | 22.65 | 15.44 | 0.0522 |
| 234 | 344.3 | 1.885 | 19.47 | 14.68 | 2.862 | 375.3 | 2.035 | 23.00 | 15.63 | 0.0522 |
| 235 | 350.0 | 1.913 | 19.77 | 14.87 | 2.883 | 381.7 | 2.067 | 23.35 | 15.82 | 0.0523 |
| 236 | 355.9 | 1.941 | 20.07 | 15.05 | 2.904 | 388.2 | 2.098 | 23.71 | 16.01 | 0.0524 |
| 237 | 361.9 | 1.970 | 20.37 | 15.23 | 2.926 | 394.9 | 2.130 | 24.08 | 16.21 | 0.0524 |
| 238 | 367.9 | 2.000 | 20.68 | 15.41 | 2.946 | 401.6 | 2.163 | 24.45 | 16.41 | 0.0525 |
| 239 | 374.1 | 2.030 | 20.99 | 15.59 | 2.967 | 408.4 | 2.196 | 24.82 | 16.61 | 0.0526 |
| 240 | 380.3 | 2.060 | 21.30 | 15.78 | 2.988 | 415.4 | 2.230 | 25.20 | 16.82 | 0.0526 |
| 241 | 386.6 | 2.090 | 21.62 | 15.97 | 3.009 | 422.4 | 2.264 | 25.58 | 17.02 | 0.0527 |
| 242 | 393.1 | 2.122 | 21.95 | 16.16 | 3.030 | 429.6 | 2.298 | 25.98 | 17.23 | 0.0528 |
| 243 | 399.6 | 2.153 | 22.27 | 16.35 | 3.051 | 436.9 | 2.334 | 26.37 | 17.45 | 0.0529 |
| 244 | 406.3 | 2.186 | 22.61 | 16.55 | 3.072 | 444.3 | 2.369 | 26.77 | 17.66 | 0.0529 |
| 245 | 413.1 | 2.219 | 22.95 | 16.75 | 3.093 | 451.9 | 2.406 | 27.18 | 17.88 | 0.0530 |
| 246 | 419.9 | 2.251 | 23.28 | 16.95 | 3.113 | 459.5 | 2.443 | 27.60 | 18.10 | 0.0531 |
| 247 | 426.9 | 2.285 | 23.64 | 17.15 | 3.134 | 467.3 | 2.480 | 28.02 | 18.33 | 0.0531 |
| 248 | 434.0 | 2.320 | 23.99 | 17.36 | 3.155 | 475.2 | 2.518 | 28.45 | 18.55 | 0.0532 |
| 249 | 441.2 | 2.354 | 24.35 | 17.57 | 3.176 | 483.3 | 2.557 | 28.89 | 18.79 | 0.0532 |
| 250 | 448.5 | 2.390 | 24.71 | 17.78 | 3.197 | 491.5 | 2.597 | 29.32 | 19.02 | 0.0533 |

TABLE 147

*Giving for each sex the weights of body, stomach, pancreas, both submaxillaries and epididymis for each millimeter of body length. Charts 39, 40, 41 and 47*

| | MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Stomach | Pancreas | Both submax-illaries | Epididymis (2) | Body weight | Stomach | Pancreas | Both submax-illaries |
| *mm.* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 47 | 4.9 | | | | 0.0047 | 4.7 | | | |
| 48 | 4.9 | 0.030 | (0.017)* | 0.017 | 0.0047 | 4.7 | 0.029 | (0.017)* | 0.016 |
| 49 | 5.0 | 0.030 | | 0.017 | 0.0047 | 4.9 | 0.030 | | 0.017 |
| 50 | 5.1 | 0.031 | | 0.017 | 0.0047 | 5.0 | 0.030 | | 0.017 |
| 51 | 5.2 | 0.031 | | 0.018 | 0.0047 | 5.1 | 0.031 | | 0.017 |
| 52 | 5.3 | 0.032 | | 0.018 | 0.0049 | 5.3 | 0.032 | | 0.018 |
| 53 | 5.4 | 0.032 | | 0.019 | 0.0049 | 5.5 | 0.033 | | 0.019 |
| 54 | 5.6 | 0.034 | | 0.019 | 0.0049 | 5.8 | 0.035 | | 0.020 |
| 55 | 5.8 | 0.035 | | 0.020 | 0.0051 | 6.2 | 0.037 | | 0.022 |
| 56 | 6.1 | 0.036 | | 0.021 | 0.0052 | 6.5 | 0.039 | | 0.023 |
| 57 | 6.4 | 0.038 | | 0.022 | 0.0053 | 6.9 | 0.041 | | 0.024 |
| 58 | 6.8 | 0.041 | | 0.024 | 0.0055 | 7.2 | 0.043 | | 0.025 |
| 59 | 7.1 | 0.042 | | 0.025 | 0.0057 | 7.6 | 0.045 | | 0.026 |
| 60 | 7.5 | 0.045 | | 0.026 | 0.0059 | 8.0 | 0.048 | | 0.028 |
| 61 | 7.9 | 0.047 | | 0.027 | 0.0061 | 8.4 | 0.051 | | 0.029 |
| 62 | 8.2 | 0.049 | | 0.028 | 0.0063 | 8.7 | 0.053 | | 0.030 |
| 63 | 8.6 | 0.052 | | 0.030 | 0.0006 | 9.1 | 0.055 | | 0.031 |
| 64 | 9.0 | 0.055 | | 0.031 | 0.0068 | 9.5 | 0.058 | | 0.033 |
| 65 | 9.4 | 0.057 | | 0.032 | 0.0071 | 9.9 | 0.061 | | 0.034 |
| 66 | 9.8 | 0.060 | | 0.034 | 0.0073 | 10.3 | 0.064 | 0.063 | 0.035 |
| 67 | 10.1 | 0.062 | 0.056 | 0.035 | 0.0074 | 10.8 | 0.067 | 0.078 | 0.037 |
| 68 | 10.6 | 0.066 | 0.072 | 0.036 | 0.0077 | 11.2 | 0.070 | 0.087 | 0.038 |
| 69 | 11.0 | 0.069 | 0.082 | 0.037 | 0.0080 | 11.6 | 0.073 | 0.095 | 0.039 |
| 70 | 11.4 | 0.072 | 0.091 | 0.038 | 0.0083 | 12.0 | 0.076 | 0.102 | 0.040 |
| 71 | 11.8 | 0.075 | 0.098 | 0.040 | 0.0086 | 12.5 | 0.080 | 0.110 | 0.042 |
| 72 | 12.2 | 0.078 | 0.105 | 0.041 | 0.0089 | 12.9 | 0.083 | 0.115 | 0.043 |
| 73 | 12.7 | 0.082 | 0.112 | 0.042 | 0.0092 | 13.4 | 0.087 | 0.122 | 0.044 |
| 74 | 13.1 | 0.085 | 0.118 | 0.043 | 0.0095 | 13.9 | 0.092 | 0.128 | 0.046 |
| 75 | 13.6 | 0.089 | 0.124 | 0.045 | 0.0100 | 14.3 | 0.095 | 0.132 | 0.047 |
| 76 | 14.0 | 0.092 | 0.129 | 0.046 | 0.0103 | 14.8 | 0.099 | 0.138 | 0.048 |
| 77 | 14.5 | 0.097 | 0.134 | 0.047 | 0.0107 | 15.3 | 0.104 | 0.143 | 0.049 |
| 78 | 15.0 | 0.101 | 0.140 | 0.049 | 0.0111 | 15.8 | 0.108 | 0.147 | 0.051 |
| 79 | 15.4 | 0.105 | 0.144 | 0.050 | 0.0114 | 16.3 | 0.113 | 0.152 | 0.052 |
| 80 | 15.9 | 0.109 | 0.148 | 0.051 | 0.0119 | 16.8 | 0.117 | 0.156 | 0.053 |

* Initial value for pancreas computed

TABLE 147—*Continued*

| MALES | | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Stomach | Pancreas | Both submaxillaries | Epididymis (2) | Body weight | Stomach | Pancreas | Both submaxillaries |
| *mm.* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 81 | 16.4 | 0.113 | 0.153 | 0.052 | 0.0123 | 17.3 | 0.122 | 0.161 | 0.055 |
| 82 | 16.9 | 0.118 | 0.157 | 0.054 | 0.0128 | 17.9 | 0.128 | 0.165 | 0.056 |
| 83 | 17.4 | 0.123 | 0.161 | 0.055 | 0.0133 | 18.4 | 0.133 | 0.169 | 0.057 |
| 84 | 18.0 | 0.129 | 0.166 | 0.056 | 0.0138 | 19.0 | 0.139 | 0.174 | 0.059 |
| 85 | 18.5 | 0.134 | 0.170 | 0.058 | 0.0142 | 19.5 | 0.144 | 0.178 | 0.060 |
| 86 | 19.0 | 0.139 | 0.174 | 0.059 | 0.0148 | 20.1 | 0.150 | 0.182 | 0.062 |
| 87 | 19.6 | 0.145 | 0.179 | 0.060 | 0.0154 | 20.7 | 0.160 | 0.188 | 0.063 |
| 88 | 20.1 | 0.150 | 0.182 | 0.062 | 0.0159 | 21.2 | 0.167 | 0.192 | 0.064 |
| 89 | 20.7 | 0.160 | 0.186 | 0.063 | 0.0166 | 21.8 | 0.176 | 0.197 | 0.066 |
| 90 | 21.3 | 0.169 | 0.189 | 0.065 | 0.0172 | 22.4 | 0.185 | 0.202 | 0.067 |
| 91 | 21.9 | 0.178 | 0.194 | 0.066 | 0.0179 | 23.1 | 0.195 | 0.207 | 0.069 |
| 92 | 22.4 | 0.185 | 0.198 | 0.067 | 0.0184 | 23.7 | 0.203 | 0.212 | 0.070 |
| 93 | 23.0 | 0.193 | 0.202 | 0.069 | 0.0191 | 24.3 | 0.211 | 0.217 | 0.072 |
| 94 | 23.7 | 0.203 | 0.206 | 0.070 | 0.0199 | 25.0 | 0.220 | 0.222 | 0.073 |
| 95 | 24.3 | 0.211 | 0.210 | 0.072 | 0.0260 | 25.6 | 0.228 | 0.227 | 0.075 |
| 96 | 24.9 | 0.219 | 0.213 | 0.073 | 0.0214 | 26.3 | 0.237 | 0.232 | 0.076 |
| 97 | 25.6 | 0.228 | 0.218 | 0.075 | 0.0222 | 27.0 | 0.245 | 0.237 | 0.078 |
| 98 | 26.2 | 0.235 | 0.221 | 0.076 | 0.0230 | 27.7 | 0.254 | 0.243 | 0.079 |
| 99 | 26.9 | 0.244 | 0.225 | 0.078 | 0.0240 | 28.4 | 0.262 | 0.248 | 0.081 |
| 100 | 27.5 | 0.251 | 0.229 | 0.079 | 0.0247 | 29.1 | 0.270 | 0.253 | 0.083 |
| 101 | 28.2 | 0.260 | 0.233 | 0.081 | 0.0257 | 29.8 | 0.278 | 0.258 | 0.084 |
| 102 | 28.9 | 0.268 | 0.237 | 0.082 | 0.0266 | 30.5 | 0.286 | 0.262 | 0.086 |
| 103 | 29.6 | 0.276 | 0.241 | 0.084 | 0.0276 | 31.3 | 0.295 | 0.268 | 0.087 |
| 104 | 30.3 | 0.284 | 0.244 | 0.085 | 0.0287 | 32.0 | 0.302 | 0.273 | 0.089 |
| 105 | 31.1 | 0.292 | 0.249 | 0.087 | 0.0298 | 32.8 | 0.310 | 0.278 | 0.091 |
| 106 | 31.8 | 0.300 | 0.252 | 0.088 | 0.0308 | 33.6 | 0.319 | 0.283 | 0.092 |
| 107 | 32.5 | 0.307 | 0.256 | 0.090 | 0.0319 | 34.4 | 0.327 | 0.289 | 0.094 |
| 108 | 33.3 | 0.316 | 0.260 | 0.092 | 0.0332 | 35.2 | 0.335 | 0.294 | 0.096 |
| 109 | 34.1 | 0.324 | 0.264 | 0.093 | 0.0345 | 36.0 | 0.342 | 0.299 | 0.097 |
| 110 | 34.9 | 0.332 | 0.268 | 0.095 | 0.0358 | 36.9 | 0.351 | 0.305 | 0.099 |
| 111 | 35.7 | 0.340 | 0.273 | 0.097 | 0.0371 | 37.7 | 0.359 | 0.310 | 0.101 |
| 112 | 36.5 | 0.347 | 0.277 | 0.098 | 0.0384 | 38.6 | 0.367 | 0.315 | 0.103 |
| 113 | 37.3 | 0.355 | 0.281 | 0.100 | 0.0398 | 39.5 | 0.375 | 0.321 | 0.105 |
| 114 | 38.2 | 0.363 | 0.285 | 0.102 | 0.0414 | 40.3 | 0.382 | 0.326 | 0.106 |
| 115 | 39.0 | 0.371 | 0.289 | 0.104 | 0.0428 | 41.3 | 0.391 | 0.332 | 0.108 |
| 116 | 39.9 | 0.379 | 0.293 | 0.105 | 0.0444 | 42.2 | 0.399 | 0.337 | 0.110 |
| 117 | 40.8 | 0.387 | 0.298 | 0.107 | 0.0461 | 43.1 | 0.406 | 0.342 | 0.112 |

TABLE 147—*Continued*

| MALES | | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Stomach | Pancreas | Both submaxillaries | Epididymus (2) | Body weight | Stomach | Pancreas | Both submaxillaries |
| *mm.* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 118 | 41.6 | 0.394 | 0.302 | 0.109 | 0.0476 | 44.1 | 0.415 | 0.348 | 0.114 |
| 119 | 42.6 | 0.402 | 0.306 | 0.111 | 0.0495 | 45.0 | 0.422 | 0.354 | 0.116 |
| 120 | 43.5 | 0.410 | 0.311 | 0.113 | 0.0512 | 46.0 | 0.430 | 0.359 | 0.118 |
| 121 | 44.4 | 0.417 | 0.315 | 0.115 | 0.0531 | 47.0 | 0.438 | 0.365 | 0.120 |
| 122 | 45.4 | 0.425 | 0.320 | 0.117 | 0.0551 | 48.0 | 0.446 | 0.371 | 0.122 |
| 123 | 46.3 | 0.433 | 0.324 | 0.118 | 0.0570 | 49.1 | 0.454 | 0.377 | 0.124 |
| 124 | 47.3 | 0.440 | 0.328 | 0.120 | 0.0591 | 50.1 | 0.462 | 0.382 | 0.126 |
| 125 | 48.3 | 0.448 | 0.333 | 0.122 | 0.0613 | 51.2 | 0.470 | 0.388 | 0.128 |
| 126 | 49.3 | 0.456 | 0.338 | 0.124 | 0.0634 | 52.3 | 0.478 | 0.394 | 0.130 |
| 127 | 50.4 | 0.464 | 0.343 | 0.126 | 0.0659 | 53.4 | 0.486 | 0.400 | 0.132 |
| 128 | 51.4 | 0.472 | 0.347 | 0.128 | 0.0681 | 54.5 | 0.494 | 0.406 | 0.134 |
| 129 | 52.5 | 0.480 | 0.352 | 0.130 | 0.0707 | 55.6 | 0.502 | 0.412 | 0.136 |
| 130 | 53.6 | 0.487 | 0.357 | 0.133 | 0.0734 | 56.8 | 0.510 | 0.419 | 0.139 |
| 131 | 54.7 | 0.495 | 0.362 | 0.135 | 0.0759 | 58.0 | 0.518 | 0.425 | 0.141 |
| 132 | 55.8 | 0.503 | 0.367 | 0.137 | 0.0787 | 59.2 | 0.526 | 0.431 | 0.143 |
| 133 | 56.9 | 0.511 | 0.372 | 0.139 | 0.0815 | 60.4 | 0.534 | 0.437 | 0.145 |
| 134 | 58.1 | 0.519 | 0.377 | 0.141 | 0.0844 | 61.6 | 0.542 | 0.444 | 0.148 |
| 135 | 59.3 | 0.527 | 0.382 | 0.143 | 0.0875 | 62.9 | 0.550 | 0.450 | 0.150 |
| 136 | 60.5 | 0.535 | 0.388 | 0.146 | 0.0907 | 64.2 | 0.559 | 0.457 | 0.153 |
| 137 | 61.7 | 0.543 | 0.393 | 0.148 | 0.0939 | 65.5 | 0.567 | 0.463 | 0.155 |
| 138 | 62.9 | 0.550 | 0.398 | 0.150 | 0.0972 | 66.8 | 0.575 | 0.470 | 0.157 |
| 139 | 64.1 | 0.558 | 0.403 | 0.152 | 0.1006 | 68.1 | 0.583 | 0.476 | 0.160 |
| 140 | 65.4 | 0.566 | 0.409 | 0.155 | 0.1042 | 69.5 | 0.591 | 0.483 | 0.162 |
| 141 | 66.7 | 0.574 | 0.414 | 0.157 | 0.1080 | 70.9 | 0.599 | 0.490 | 0.165 |
| 142 | 68.0 | 0.582 | 0.420 | 0.160 | 0.1118 | 72.3 | 0.608 | 0.497 | 0.167 |
| 143 | 69.3 | 0.590 | 0.425 | 0.162 | 0.1156 | 73.7 | 0.616 | 0.504 | 0.170 |
| 144 | 70.7 | 0.598 | 0.431 | 0.165 | 0.1200 | 75.2 | 0.624 | 0.511 | 0.173 |
| 145 | 72.1 | 0.606 | 0.437 | 0.167 | 0.1243 | 76.7 | 0.633 | 0.518 | 0.175 |
| 146 | 73.5 | 0.615 | 0.443 | 0.170 | 0.1286 | 78.2 | 0.641 | 0.526 | 0.178 |
| 147 | 74.9 | 0.623 | 0.449 | 0.172 | 0.1332 | 79.7 | 0.649 | 0.533 | 0.181 |
| 148 | 76.3 | 0.631 | 0.455 | 0.175 | 0.1377 | 81.3 | 0.658 | 0.540 | 0.184 |
| 149 | 77.8 | 0.639 | 0.461 | 0.178 | 0.1428 | 82.8 | 0.666 | 0.547 | 0.186 |
| 150 | 79.3 | 0.647 | 0.467 | 0.180 | 0.1478 | 84.4 | 0.675 | 0.555 | 0.189 |
| 151 | 80.8 | 0.655 | 0.474 | 0.183 | 0.1530 | 86.1 | 0.684 | 0.563 | 0.192 |
| 152 | 82.4 | 0.664 | 0.480 | 0.186 | 0.1586 | 87.7 | 0.692 | 0.570 | 0.195 |
| 153 | 83.9 | 0.672 | 0.486 | 0.188 | 0.1639 | 89.4 | 0.701 | 0.578 | 0.198 |
| 154 | 85.5 | 0.681 | 0.493 | 0.191 | 0.1697 | 91.1 | 0.709 | 0.586 | 0.201 |

TABLE 147—*Continued*

| MALES | | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Stomach | Pancreas | Both submaxillaries | Epididymis (2) | Body weight | Stomach | Pancreas | Both submaxillaries |
| *mm.* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 155 | 87.1 | 0.689 | 0.500 | 0.194 | 0.1756 | 92.9 | 0.718 | 0.594 | 0.204 |
| 156 | 88.7 | 0.697 | 0.506 | 0.197 | 0.1817 | 94.6 | 0.727 | 0.602 | 0.207 |
| 157 | 90.4 | 0.706 | 0.513 | 0.200 | 0.1881 | 96.4 | 0.736 | 0.610 | 0.210 |
| 158 | 92.1 | 0.714 | 0.520 | 0.203 | 0.1947 | 98.3 | 0.745 | 0.618 | 0.214 |
| 159 | 93.8 | 0.723 | 0.527 | 0.206 | 0.2015 | 100.1 | 0.754 | 0.626 | 0.217 |
| 160 | 95.6 | 0.732 | 0.534 | 0.209 | 0.2087 | 102.0 | 0.763 | 0.635 | 0.220 |
| 161 | 97.3 | 0.740 | 0.541 | 0.212 | 0.2167 | 103.9 | 0.772 | 0.643 | 0.224 |
| 162 | 99.2 | 0.749 | 0.549 | 0.215 | 0.2236 | 105.9 | 0.781 | 0.652 | 0.227 |
| 163 | 101.0 | 0.758 | 0.556 | 0.219 | 0.2356 | 107.9 | 0.790 | 0.661 | 0.231 |
| 164 | 102.8 | 0.766 | 0.563 | 0.222 | 0.2470 | 109.9 | 0.799 | 0.670 | 0.234 |
| 165 | 104.7 | 0.775 | 0.571 | 0.225 | 0.2585 | 111.9 | 0.808 | 0.678 | 0.237 |
| 166 | 106.7 | 0.785 | 0.579 | 0.228 | 0.2707 | 114.0 | 0.818 | 0.688 | 0.241 |
| 167 | 108.6 | 0.793 | 0.586 | 0.232 | 0.2818 | 116.1 | 0.827 | 0.697 | 0.245 |
| 168 | 110.6 | 0.802 | 0.594 | 0.235 | 0.2935 | 118.3 | 0.836 | 0.706 | 0.248 |
| 169 | 112.6 | 0.811 | 0.602 | 0.239 | 0.3047 | 120.5 | 0.846 | 0.716 | 0.252 |
| 170 | 114.7 | 0.821 | 0.611 | 0.242 | 0.3164 | 122.7 | 0.855 | 0.725 | 0.256 |
| 171 | 116.7 | 0.829 | 0.619 | 0.246 | 0.3273 | 125.0 | 0.865 | 0.735 | 0.260 |
| 172 | 118.9 | 0.839 | 0.627 | 0.249 | 0.3390 | 127.3 | 0.875 | 0.744 | 0.264 |
| 173 | 121.0 | 0.848 | 0.636 | 0.253 | 0.3499 | 129.6 | 0.885 | 0.754 | 0.268 |
| 174 | 123.2 | 0.858 | 0.644 | 0.257 | 0.3610 | 132.0 | 0.894 | 0.764 | 0.272 |
| 175 | 125.4 | 0.867 | 0.653 | 0.260 | 0.3721 | 134.4 | 0.904 | 0.774 | 0.276 |
| 176 | 127.7 | 0.877 | 0.662 | 0.264 | 0.3834 | 136.8 | 0.914 | 0.785 | 0.280 |
| 177 | 130.0 | 0.886 | 0.671 | 0.268 | 0.3943 | 139.3 | 0.924 | 0.795 | 0.284 |
| 178 | 132.2 | 0.896 | 0.680 | 0.272 | 0.4053 | 141.9 | 0.934 | 0.806 | 0.288 |
| 179 | 134.6 | 0.905 | 0.689 | 0.276 | 0.4158 | 144.4 | 0.944 | 0.816 | 0.293 |
| 180 | 137.0 | 0.915 | 0.698 | 0.280 | 0.4267 | 147.1 | 0.955 | 0.827 | 0.297 |
| 181 | 139.5 | 0.925 | 0.708 | 0.284 | 0.4378 | 149.7 | 0.965 | 0.838 | 0.301 |
| 182 | 142.0 | 0.935 | 0.718 | 0.289 | 0.4486 | 152.4 | 0.975 | 0.849 | 0.306 |
| 183 | 144.5 | 0.945 | 0.728 | 0.293 | 0.4592 | 155.2 | 0.986 | 0.860 | 0.311 |
| 184 | 147.0 | 0.955 | 0.737 | 0.297 | 0.4695 | 158.0 | 0.997 | 0.872 | 0.315 |
| 185 | 149.6 | 0.965 | 0.748 | 0.301 | 0.4801 | 160.8 | 1.007 | 0.883 | 0.320 |
| 186 | 152.3 | 0.975 | 0.758 | 0.306 | 0.4909 | 163.7 | 1.018 | 0.895 | 0.325 |
| 187 | 155.0 | 0.985 | 0.768 | 0.310 | 0.5014 | 166.6 | 1.029 | 0.907 | 0.330 |
| 188 | 157.7 | 0.996 | 0.779 | 0.315 | 0.5117 | 169.6 | 1.040 | 0.919 | 0.335 |
| 189 | 160.5 | 1.006 | 0.790 | 0.320 | 0.5223 | 172.6 | 1.051 | 0.931 | 0.340 |
| 190 | 163.3 | 1.017 | 0.801 | 0.324 | 0.5326 | 175.7 | 1.062 | 0.943 | 0.345 |

TABLE 147—*Continued*

| MALES | | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Stomach | Pancreas | Both submaxillaries | Epididymis (2) | Body weight | Stomach | Pancreas | Both submaxillaries |
| *mm.* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 191 | 166.2 | 1.027 | 0.812 | 0.329 | 0.5429 | 178.8 | 1.073 | 0.956 | 0.350 |
| 192 | 169.1 | 1.038 | 0.823 | 0.334 | 0.5530 | 182.0 | 1.084 | 0.968 | 0.355 |
| 193 | 172.0 | 1.049 | 0.834 | 0.338 | 0.5630 | 185.2 | 1.096 | 0.981 | 0.360 |
| 194 | 175.0 | 1.059 | 0.845 | 0.343 | 0.5731 | 188.5 | 1.107 | 0.994 | 0.366 |
| 195 | 178.1 | 1.071 | 0.857 | 0.349 | 0.5835 | 191.9 | 1.119 | 1.008 | 0.371 |
| 196 | 181.2 | 1.082 | 0.869 | 0.354 | 0.5934 | 195.3 | 1.131 | 1.021 | 0.377 |
| 197 | 184.3 | 1.093 | 0.881 | 0.359 | 0.6032 | 198.7 | 1.143 | 1.035 | 0.382 |
| 198 | 187.5 | 1.104 | 0.893 | 0.364 | 0.6131 | 202.2 | 1.155 | 1.048 | 0.388 |
| 199 | 190.8 | 1.115 | 0.906 | 0.369 | 0.6231 | 205.8 | 1.167 | 1.062 | 0.394 |
| 200 | 194.1 | 1.127 | 0.919 | 0.375 | 0.6328 | 209.4 | 1.179 | 1.076 | 0.400 |
| 201 | 197.4 | 1.138 | 0.931 | 0.380 | 0.6423 | 213.1 | 1.191 | 1.091 | 0.406 |
| 202 | 200.8 | 1.150 | 0.944 | 0.386 | 0.6520 | 216.8 | 1.203 | 1.105 | 0.412 |
| 203 | 204.3 | 1.162 | 0.957 | 0.392 | 0.6618 | 220.7 | 1.216 | 1.120 | 0.418 |
| 204 | 207.8 | 1.173 | 0.971 | 0.397 | 0.6712 | 224.5 | 1.229 | 1.135 | 0.424 |
| 205 | 211.4 | 1.185 | 0.984 | 0.403 | 0.6808 | 228.4 | 1.241 | 1.150 | 0.431 |
| 206 | 215.0 | 1.197 | 0.998 | 0.409 | 0.6902 | 232.4 | 1.254 | 1.166 | 0.437 |
| 207 | 218.7 | 1.210 | 1.012 | 0.415 | 0.6996 | 236.5 | 1.267 | 1.181 | 0.444 |
| 208 | 222.5 | 1.222 | 1.026 | 0.421 | 0.7090 | 240.6 | 1.280 | 1.197 | 0.450 |
| 209 | 226.3 | 1.235 | 1.041 | 0.427 | 0.7184 | 244.8 | 1.294 | 1.213 | 0.457 |
| 210 | 230.2 | 1.247 | 1.055 | 0.434 | 0.7276 | 249.1 | 1.307 | 1.230 | 0.464 |
| 211 | 234.1 | 1.260 | 1.070 | 0.440 | 0.7366 | 253.4 | 1.321 | 1.246 | 0.471 |
| 212 | 238.1 | 1.273 | 1.085 | 0.446 | 0.7458 | 257.8 | 1.334 | 1.263 | 0.478 |
| 213 | 242.2 | 1.286 | 1.101 | 0.453 | 0.7548 | 262.3 | 1.348 | 1.280 | 0.485 |
| 214 | 246.3 | 1.299 | 1.116 | 0.460 | 0.7638 | 266.9 | 1.363 | 1.297 | 0.493 |
| 215 | 250.5 | 1.312 | 1.132 | 0.467 | 0.7726 | 271.5 | 1.377 | 1.315 | 0.500 |
| 216 | 254.7 | 1.325 | 1.148 | 0.473 | 0.7813 | 276.2 | 1.391 | 1.333 | 0.508 |
| 217 | 259.1 | 1.339 | 1.164 | 0.480 | 0.7904 | 281.0 | 1.405 | 1.351 | 0.515 |
| 218 | 263.5 | 1.352 | 1.181 | 0.487 | 0.7990 | 285.8 | 1.420 | 1.369 | 0.523 |
| 219 | 267.9 | 1.366 | 1.197 | 0.494 | 0.8076 | 290.8 | 1.435 | 1.388 | 0.531 |
| 220 | 272.5 | 1.380 | 1.215 | 0.502 | 0.8163 | 295.8 | 1.450 | 1.407 | 0.539 |
| 221 | 277.1 | 1.394 | 1.232 | 0.509 | 0.8246 | 300.9 | 1.465 | 1.426 | 0.547 |
| 222 | 281.8 | 1.408 | 1.249 | 0.517 | 0.8331 | 306.1 | 1.480 | 1.445 | 0.556 |
| 223 | 286.5 | 1.422 | 1.267 | 0.524 | 0.8414 | 311.3 | 1.495 | 1.465 | 0.564 |
| 224 | 291.4 | 1.437 | 1.285 | 0.532 | 0.8499 | 316.7 | 1.511 | 1.485 | 0.573 |
| 225 | 296.3 | 1.451 | 1.304 | 0.540 | 0.8580 | 322.1 | 1.527 | 1.505 | 0.581 |
| 226 | 301.3 | 1.466 | 1.322 | 0.548 | 0.8663 | 327.7 | 1.543 | 1.526 | 0.590 |
| 227 | 306.4 | 1.481 | 1.341 | 0.556 | 0.8744 | 333.3 | 1.559 | 1.547 | 0.599 |

TABLE 147—*Concluded*

| MALES | | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Stomach | Pancreas | Both submaxillaries | Epididymis (2) | Body weight | Stomach | Pancreas | Both submaxillaries |
| *mm.* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 228 | 311.5 | 1.496 | 1.360 | 0.564 | 0.8824 | 339.0 | 1.575 | 1.568 | 0.608 |
| 229 | 316.8 | 1.511 | 1.380 | 0.573 | 0.8904 | 344.8 | 1.592 | 1.589 | 0.617 |
| 230 | 322.1 | 1.527 | 1.400 | 0.581 | 0.8983 | 350.7 | 1.608 | 1.611 | 0.627 |
| 231 | 327.5 | 1.542 | 1.420 | 0.590 | 0.9060 | 356.7 | 1.625 | 1.633 | 0.636 |
| 232 | 333.0 | 1.558 | 1.440 | 0.599 | 0.9138 | 362.8 | 1.642 | 1.656 | 0.646 |
| 233 | 338.6 | 1.574 | 1.461 | 0.607 | 0.9215 | 369.0 | 1.660 | 1.678 | 0.656 |
| 234 | 344.3 | 1.590 | 1.482 | 0.616 | 0.9290 | 375.3 | 1.677 | 1.702 | 0.666 |
| 235 | 350.0 | 1.606 | 1.504 | 0.625 | 0.9366 | 381.7 | 1.695 | 1.725 | 0.676 |
| 236 | 355.9 | 1.623 | 1.525 | 0.635 | 0.9439 | 388.2 | 1.713 | 1.749 | 0.686 |
| 237 | 361.9 | 1.640 | 1.548 | 0.644 | 0.9514 | 394.9 | 1.731 | 1.774 | 0.696 |
| 238 | 367.9 | 1.657 | 1.570 | 0.654 | 0.9586 | 401.6 | 1.749 | 1.798 | 0.707 |
| 239 | 374.1 | 1.674 | 1.593 | 0.664 | 0.9659 | 408.4 | 1.768 | 1.823 | 0.718 |
| 240 | 380.3 | 1.691 | 1.616 | 0.674 | 0.9729 | 415.4 | 1.787 | 1.849 | 0.729 |
| 241 | 386.6 | 1.708 | 1.639 | 0.683 | 0.9799 | 422.4 | 1.806 | 1.874 | 0.740 |
| 242 | 393.1 | 1.726 | 1.663 | 0.694 | 0.9869 | 429.6 | 1.825 | 1.900 | 0.751 |
| 243 | 399.6 | 1.744 | 1.688 | 0.704 | 0.9936 | 436.9 | 1.844 | 1.927 | 0.763 |
| 244 | 406.3 | 1.762 | 1.712 | 0.715 | 1.0004 | 444.3 | 1.864 | 1.954 | 0.774 |
| 245 | 413.1 | 1.781 | 1.737 | 0.725 | 1.0073 | 451.9 | 1.884 | 1.981 | 0.786 |
| 246 | 419.9 | 1.799 | 1.762 | 0.736 | 1.0136 | 459.5 | 1.904 | 2.009 | 0.798 |
| 247 | 426.9 | 1.818 | 1.788 | 0.747 | 1.0202 | 467.3 | 1.925 | 2.037 | 0.810 |
| 248 | 434.0 | 1.837 | 1.815 | 0.758 | 1.0267 | 475.2 | 1.946 | 2.066 | 0.823 |
| 249 | 441.2 | 1.856 | 1.841 | 0.769 | 1.0329 | 483.3 | 1.967 | 2.095 | 0.836 |
| 250 | 448.5 | 1.875 | 1.868 | 0.781 | 1.0392 | 491.5 | 1.988 | 2.125 | 0.848 |

TABLE 148

*Giving for each sex the weights of body, hypophysis, suprarenals and thyroid for each millimeter of body length. See Charts 42, 43 and 44*

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Hypophysis | Suprarenals | Thyroid | Body weight | Hypophysis | Suprarenals | Thyroid |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 50 | 5.1 | 0.0005 | 0.0017 | 0.0015 | 5.0 | 0.0005 | 0.0017 | 0.0014 |
| 51 | 5.2 | 0.0005 | 0.0017 | 0.0015 | 5.1 | 0.0005 | 0.0017 | 0.0015 |
| 52 | 5.3 | 0.0005 | 0.0017 | 0.0015 | 5.3 | 0.0005 | 0.0018 | 0.0015 |
| 53 | 5.4 | 0.0005 | 0.0018 | 0.0016 | 5.5 | 0.0006 | 0.0019 | 0.0016 |
| 54 | 5.6 | 0.0005 | 0.0019 | 0.0016 | 5.8 | 0.0006 | 0.0021 | 0.0017 |
| 55 | 5.8 | 0.0006 | 0.0021 | 0.0017 | 6.2 | 0.0006 | 0.0024 | 0.0018 |
| 56 | 6.1 | 0.0006 | 0.0023 | 0.0018 | 6.5 | 0.0006 | 0.0026 | 0.0019 |
| 57 | 6.4 | 0.0006 | 0.0025 | 0.0018 | 6.9 | 0.0007 | 0.0028 | 0.0020 |
| 58 | 6.8 | 0.0007 | 0.0027 | 0.0019 | 7.2 | 0.0007 | 0.0030 | 0.0021 |
| 59 | 7.1 | 0.0007 | 0.0029 | 0.0020 | 7.6 | 0.0007 | 0.0032 | 0.0022 |
| 60 | 7.5 | 0.0007 | 0.0031 | 0.0021 | 8.0 | 0.0008 | 0.0034 | 0.0023 |
| 61 | 7.9 | 0.0008 | 0.0034 | 0.0022 | 8.4 | 0.0008 | 0.0036 | 0.0024 |
| 62 | 8.2 | 0.0008 | 0.0035 | 0.0023 | 8.7 | 0.0008 | 0.0038 | 0.0025 |
| 63 | 8.6 | 0.0008 | 0.0037 | 0.0024 | 9.1 | 0.0009 | 0.0040 | 0.0026 |
| 64 | 9.0 | 0.0009 | 0.0039 | 0.0025 | 9.5 | 0.0009 | 0.0042 | 0.0027 |
| 65 | 9.4 | 0.0009 | 0.0041 | 0.0026 | 9.9 | 0.0009 | 0.0044 | 0.0028 |
| 66 | 9.8 | 0.0009 | 0.0043 | 0.0027 | 10.3 | 0.0009 | 0.0045 | 0.0029 |
| 67 | 10.1 | 0.0009 | 0.0045 | 0.0028 | 10.8 | 0.0010 | 0.0048 | 0.0030 |
| 68 | 10.6 | 0.0010 | 0.0047 | 0.0030 | 11.2 | 0.0010 | 0.0049 | 0.0031 |
| 69 | 11.0 | 0.0010 | 0.0049 | 0.0031 | 11.6 | 0.0010 | 0.0051 | 0.0032 |
| 70 | 11.4 | 0.0010 | 0.0050 | 0.0032 | 12.0 | 0.0011 | 0.0053 | 0.0033 |
| 71 | 11.8 | 0.0011 | 0.0052 | 0.0033 | 12.5 | 0.0011 | 0.0055 | 0.0034 |
| 72 | 12.2 | 0.0011 | 0.0054 | 0.0034 | 12.9 | 0.0011 | 0.0056 | 0.0035 |
| 73 | 12.7 | 0.0011 | 0.0056 | 0.0035 | 13.4 | 0.0012 | 0.0058 | 0.0037 |
| 74 | 13.1 | 0.0011 | 0.0057 | 0.0036 | 13.9 | 0.0012 | 0.0060 | 0.0038 |
| 75 | 13.6 | 0.0012 | 0.0059 | 0.0037 | 14.3 | 0.0012 | 0.0062 | 0.0039 |
| 76 | 14.0 | 0.0012 | 0.0061 | 0.0038 | 14.8 | 0.0012 | 0.0064 | 0.0040 |
| 77 | 14.5 | 0.0012 | 0.0063 | 0.0039 | 15.3 | 0.0013 | 0.0065 | 0.0041 |
| 78 | 15.0 | 0.0013 | 0.0064 | 0.0041 | 15.8 | 0.0013 | 0.0067 | 0.0042 |
| 79 | 15.4 | 0.0013 | 0.0066 | 0.0042 | 16.3 | 0.0013 | 0.0069 | 0.0044 |
| 80 | 15.9 | 0.0013 | 0.0067 | 0.0043 | 16.8 | 0.0014 | 0.0070 | 0.0045 |
| 81 | 16.4 | 0.0013 | 0.0069 | 0.0044 | 17.3 | 0.0014 | 0.0072 | 0.0046 |
| 82 | 16.9 | 0.0014 | 0.0071 | 0.0045 | 17.9 | 0.0014 | 0.0074 | 0.0047 |
| 83 | 17.4 | 0.0014 | 0.0072 | 0.0046 | 18.4 | 0.0014 | 0.0076 | 0.0049 |

TABLE 148—Continued

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Hypophysis | Suprarenals | Thyroid | Body weight | Hypophysis | Suprarenals | Thyroid |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 84 | 18.0 | 0.0014 | 0.0074 | 0.0048 | 19.0 | 0.0015 | 0.0078 | 0.0050 |
| 85 | 18.5 | 0.0015 | 0.0076 | 0.0049 | 19.5 | 0.0015 | 0.0079 | 0.0051 |
| 86 | 19.0 | 0.0015 | 0.0078 | 0.0050 | 20.1 | 0.0015 | 0.0081 | 0.0052 |
| 87 | 19.6 | 0.0015 | 0.0079 | 0.0051 | 20.7 | 0.0016 | 0.0083 | 0.0054 |
| 88 | 20.1 | 0.0015 | 0.0081 | 0.0052 | 21.2 | 0.0016 | 0.0084 | 0.0055 |
| 89 | 20.7 | 0.0016 | 0.0083 | 0.0054 | 21.8 | 0.0016 | 0.0086 | 0.0056 |
| 90 | 21.3 | 0.0016 | 0.0084 | 0.0055 | 22.4 | 0.0017 | 0.0087 | 0.0058 |
| 91 | 21.9 | 0.0016 | 0.0086 | 0.0056 | 23.1 | 0.0017 | 0.0089 | 0.0059 |
| 92 | 22.4 | 0.0017 | 0.0087 | 0.0058 | 23.7 | 0.0017 | 0.0091 | 0.0060 |
| 93 | 23.0 | 0.0017 | 0.0089 | 0.0059 | 24.3 | 0.0017 | 0.0093 | 0.0062 |
| 94 | 23.7 | 0.0017 | 0.0091 | 0.0060 | 25.0 | 0.0018 | 0.0094 | 0.0063 |
| 95 | 24.3 | 0.0017 | 0.0093 | 0.0062 | 25.6 | 0.0018 | 0.0096 | 0.0064 |
| 96 | 24.9 | 0.0018 | 0.0094 | 0.0063 | 26.3 | 0.0018 | 0.0098 | 0.0066 |
| 97 | 25.6 | 0.0018 | 0.0096 | 0.0064 | 27.0 | 0.0019 | 0.0100 | 0.0067 |
| 98 | 26.2 | 0.0018 | 0.0098 | 0.0066 | 27.7 | 0.0019 | 0.0101 | 0.0069 |
| 99 | 26.9 | 0.0019 | 0.0099 | 0.0067 | 28.4 | 0.0019 | 0.0103 | 0.0070 |
| 100 | 27.5 | 0.0019 | 0.0101 | 0.0068 | 29.1 | 0.0020 | 0.0105 | 0.0072 |
| 101 | 28.2 | 0.0019 | 0.0103 | 0.0070 | 29.8 | 0.0020 | 0.0106 | 0.0073 |
| 102 | 28.9 | 0.0020 | 0.0104 | 0.0071 | 30.5 | 0.0020 | 0.0108 | 0.0075 |
| 103 | 29.6 | 0.0020 | 0.0106 | 0.0073 | 31.3 | 0.0021 | 0.0110 | 0.0076 |
| 104 | 30.3 | 0.0020 | 0.0108 | 0.0074 | 32.0 | 0.0021 | 0.0112 | 0.0078 |
| 105 | 31.1 | 0.0021 | 0.0109 | 0.0076 | 32.8 | 0.0021 | 0.0114 | 0.0079 |
| 106 | 31.8 | 0.0021 | 0.0111 | 0.0077 | 33.6 | 0.0022 | 0.0117 | 0.0081 |
| 107 | 32.5 | 0.0021 | 0.0113 | 0.0079 | 34.4 | 0.0022 | 0.0119 | 0.0082 |
| 108 | 33.3 | 0.0021 | 0.0114 | 0.0080 | 35.2 | 0.0022 | 0.0121 | 0.0084 |
| 109 | 34.1 | 0.0022 | 0.0116 | 0.0082 | 36.0 | 0.0023 | 0.0123 | 0.0085 |
| 110 | 34.9 | 0.0022 | 0.0118 | 0.0083 | 36.9 | 0.0023 | 0.0126 | 0.0087 |
| 111 | 35.7 | 0.0022 | 0.0120 | 0.0085 | 37.7 | 0.0023 | 0.0128 | 0.0089 |
| 112 | 36.5 | 0.0023 | 0.0121 | 0.0086 | 38.6 | 0.0024 | 0.0130 | 0.0090 |
| 113 | 37.3 | 0.0023 | 0.0123 | 0.0088 | 39.5 | 0.0024 | 0.0133 | 0.0092 |
| 114 | 38.2 | 0.0024 | 0.0125 | 0.0090 | 40.3 | 0.0024 | 0.0135 | 0.0094 |
| 115 | 39.0 | 0.0024 | 0.0126 | 0.0091 | 41.3 | 0.0025 | 0.0138 | 0.0096 |
| 116 | 39.9 | 0.0024 | 0.0128 | 0.0093 | 42.2 | 0.0025 | 0.0140 | 0.0097 |
| 117 | 40.8 | 0.0025 | 0.0130 | 0.0095 | 43.1 | 0.0025 | 0.0143 | 0.0099 |
| 118 | 41.6 | 0.0025 | 0.0132 | 0.0096 | 44.1 | 0.0026 | 0.0145 | 0.0101 |
| 119 | 42.6 | 0.0025 | 0.0134 | 0.0098 | 45.0 | 0.0026 | 0.0148 | 0.0102 |
| 120 | 43.5 | 0.0026 | 0.0135 | 0.0100 | 46.0 | 0.0027 | 0.0150 | 0.0104 |

TABLE 148—Continued

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Hypophysis | Suprarenals | Thyroid | Body weight | Hypophysis | Suprarenals | Thyroid |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 121 | 44.4 | 0.0026 | 0.0137 | 0.0101 | 47.0 | 0.0027 | 0.0153 | 0.0106 |
| 122 | 45.4 | 0.0026 | 0.0139 | 0.0103 | 48.0 | 0.0027 | 0.0156 | 0.0108 |
| 123 | 46.3 | 0.0027 | 0.0141 | 0.0105 | 49.1 | 0.0028 | 0.0159 | 0.0110 |
| 124 | 47.3 | 0.0027 | 0.0142 | 0.0106 | 50.1 | 0.0028 | 0.0161 | 0.0111 |
| 125 | 48.3 | 0.0027 | 0.0144 | 0.0108 | 51.2 | 0.0029 | 0.0164 | 0.0113 |
| 126 | 49.3 | 0.0028 | 0.0146 | 0.0110 | 52.3 | 0.0029 | 0.0167 | 0.0115 |
| 127 | 50.4 | 0.0028 | 0.0148 | 0.0112 | 53.4 | 0.0030 | 0.0170 | 0.0117 |
| 128 | 51.4 | 0.0029 | 0.0150 | 0.0114 | 54.5 | 0.0031 | 0.0173 | 0.0119 |
| 129 | 52.5 | 0.0029 | 0.0152 | 0.0116 | 55.6 | 0.0031 | 0.0176 | 0.0121 |
| 130 | 53.6 | 0.0029 | 0.0154 | 0.0117 | 56.8 | 0.0032 | 0.0179 | 0.0123 |
| 131 | 54.7 | 0.0030 | 0.0155 | 0.0119 | 58.0 | 0.0033 | 0.0182 | 0.0125 |
| 132 | 55.8 | 0.0030 | 0.0157 | 0.0121 | 59.2 | 0.0034 | 0.0185 | 0.0127 |
| 133 | 56.9 | 0.0031 | 0.0159 | 0.0123 | 60.4 | 0.0035 | 0.0188 | 0.0129 |
| 134 | 58.1 | 0.0031 | 0.0161 | 0.0125 | 61.6 | 0.0035 | 0.0191 | 0.0131 |
| 135 | 59.3 | 0.0031 | 0.0163 | 0.0127 | 62.9 | 0.0036 | 0.0195 | 0.0133 |
| 136 | 60.5 | 0.0032 | 0.0165 | 0.0129 | 64.2 | 0.0037 | 0.0198 | 0.0135 |
| 137 | 61.7 | 0.0032 | 0.0167 | 0.0131 | 65.5 | 0.0038 | 0.0201 | 0.0137 |
| 138 | 62.9 | 0.0033 | 0.0169 | 0.0133 | 66.8 | 0.0039 | 0.0204 | 0.0139 |
| 139 | 64.1 | 0.0033 | 0.0171 | 0.0135 | 68.1 | 0.0040 | 0.0208 | 0.0142 |
| 140 | 65.4 | 0.0034 | 0.0173 | 0.0137 | 69.5 | 0.0041 | 0.0211 | 0.0144 |
| 141 | 66.7 | 0.0034 | 0.0175 | 0.0139 | 70.9 | 0.0042 | 0.0215 | 0.0146 |
| 142 | 68.0 | 0.0034 | 0.0177 | 0.0141 | 72.3 | 0.0043 | 0.0218 | 0.0148 |
| 143 | 69.3 | 0.0035 | 0.0179 | 0.0143 | 73.7 | 0.0044 | 0.0222 | 0.0150 |
| 144 | 70.7 | 0.0035 | 0.0181 | 0.0146 | 75.2 | 0.0045 | 0.0226 | 0.0153 |
| 145 | 72.1 | 0.0036 | 0.0183 | 0.0148 | 76.7 | 0.0046 | 0.0230 | 0.0155 |
| 146 | 73.5 | 0.0036 | 0.0185 | 0.0150 | 78.2 | 0.0047 | 0.0233 | 0.0158 |
| 147 | 74.9 | 0.0037 | 0.0187 | 0.0152 | 79.7 | 0.0048 | 0.0237 | 0.0160 |
| 148 | 76.3 | 0.0037 | 0.0189 | 0.0155 | 81.3 | 0.0049 | 0.0241 | 0.0162 |
| 149 | 77.8 | 0.0038 | 0.0192 | 0.0157 | 82.8 | 0.0050 | 0.0245 | 0.0164 |
| 150 | 79.3 | 0.0038 | 0.0194 | 0.0159 | 84.4 | 0.0051 | 0.0249 | 0.0167 |
| 151 | 80.8 | 0.0039 | 0.0196 | 0.0161 | 86.1 | 0.0052 | 0.0253 | 0.0169 |
| 152 | 82.4 | 0.0039 | 0.0198 | 0.0164 | 87.7 | 0.0053 | 0.0257 | 0.0172 |
| 153 | 83.9 | 0.0040 | 0.0200 | 0.0166 | 89.4 | 0.0055 | 0.0261 | 0.0175 |
| 154 | 85.5 | 0.0040 | 0.0203 | 0.0169 | 91.1 | 0.0056 | 0.0266 | 0.0177 |
| 155 | 87.1 | 0.0041 | 0.0205 | 0.0171 | 92.9 | 0.0057 | 0.0270 | 0.0180 |
| 156 | 88.7 | 0.0041 | 0.0207 | 0.0173 | 94.6 | 0.0058 | 0.0274 | 0.0182 |
| 157 | 90.4 | 0.0042 | 0.0210 | 0.0176 | 96.4 | 0.0060 | 0.0279 | 0.0185 |

TABLE 148—Continued

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Hypophysis | Suprarenals | Thyroid | Body weight | Hypophysis | Suprarenals | Thyroid |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 158 | 92.1 | 0.0042 | 0.0212 | 0.0179 | 98.3 | 0.0061 | 0.0283 | 0.0188 |
| 159 | 93.8 | 0.0043 | 0.0214 | 0.0181 | 100.1 | 0.0062 | 0.0288 | 0.0190 |
| 160 | 95.6 | 0.0044 | 0.0217 | 0.0184 | 102.0 | 0.0064 | 0.0293 | 0.0193 |
| 161 | 97.3 | 0.0044 | 0.0219 | 0.0186 | 103.9 | 0.0065 | 0.0297 | 0.0196 |
| 162 | 99.2 | 0.0045 | 0.0222 | 0.0189 | 105.9 | 0.0067 | 0.0302 | 0.0199 |
| 163 | 101.0 | 0.0045 | 0.0224 | 0.0191 | 107.9 | 0.0068 | 0.0307 | 0.0201 |
| 164 | 102.8 | 0.0046 | 0.0226 | 0.0194 | 109.9 | 0.0070 | 0.0312 | 0.0204 |
| 165 | 104.7 | 0.0046 | 0.0229 | 0.0197 | 111.9 | 0.0071 | 0.0317 | 0.0207 |
| 166 | 106.7 | 0.0047 | 0.0231 | 0.0200 | 114.0 | 0.0073 | 0.0322 | 0.0210 |
| 167 | 108.6 | 0.0048 | 0.0234 | 0.0202 | 116.1 | 0.0074 | 0.0327 | 0.0213 |
| 168 | 110.6 | 0.0048 | 0.0236 | 0.0205 | 118.3 | 0.0076 | 0.0333 | 0.0216 |
| 169 | 112.6 | 0.0049 | 0.0239 | 0.0208 | 120.5 | 0.0077 | 0.0338 | 0.0219 |
| 170 | 114.7 | 0.0050 | 0.0242 | 0.0211 | 122.7 | 0.0079 | 0.0343 | 0.0222 |
| 171 | 116.7 | 0.0050 | 0.0244 | 0.0214 | 125.0 | 0.0081 | 0.0349 | 0.0225 |
| 172 | 118.9 | 0.0051 | 0.0247 | 0.0217 | 127.3 | 0.0082 | 0.0355 | 0.0228 |
| 173 | 121.0 | 0.0052 | 0.0250 | 0.0220 | 129.6 | 0.0084 | 0.0360 | 0.0232 |
| 174 | 123.2 | 0.0052 | 0.0252 | 0.0223 | 132.0 | 0.0086 | 0.0366 | 0.0235 |
| 175 | 125.4 | 0.0053 | 0.0255 | 0.0226 | 134.4 | 0.0088 | 0.0372 | 0.0238 |
| 176 | 127.7 | 0.0054 | 0.0258 | 0.0229 | 136.8 | 0.0089 | 0.0378 | 0.0241 |
| 177 | 130.0 | 0.0054 | 0.0261 | 0.0232 | 139.3 | 0.0091 | 0.0384 | 0.0245 |
| 178 | 132.3 | 0.0055 | 0.0264 | 0.0235 | 141.9 | 0.0093 | 0.0390 | 0.0248 |
| 179 | 134.6 | 0.0056 | 0.0266 | 0.0238 | 144.4 | 0.0095 | 0.0396 | 0.0251 |
| 180 | 137.0 | 0.0056 | 0.0269 | 0.0242 | 147.1 | 0.0097 | 0.0402 | 0.0255 |
| 181 | 139.5 | 0.0057 | 0.0272 | 0.0245 | 149.7 | 0.0099 | 0.0409 | 0.0258 |
| 182 | 142.0 | 0.0058 | 0.0275 | 0.0248 | 152.4 | 0.0101 | 0.0415 | 0.0262 |
| 183 | 144.5 | 0.0059 | 0.0278 | 0.0252 | 155.2 | 0.0103 | 0.0422 | 0.0266 |
| 184 | 147.0 | 0.0059 | 0.0281 | 0.0255 | 158.0 | 0.0105 | 0.0429 | 0.0269 |
| 185 | 149.6 | 0.0060 | 0.0284 | 0.0258 | 160.8 | 0.0108 | 0.0435 | 0.0273 |
| 186 | 152.3 | 0.0061 | 0.0287 | 0.0262 | 163.7 | 0.0110 | 0.0442 | 0.0277 |
| 187 | 155.0 | 0.0062 | 0.0291 | 0.0265 | 166.6 | 0.0112 | 0.0449 | 0.0280 |
| 188 | 157.7 | 0.0063 | 0.0294 | 0.0269 | 169.6 | 0.0114 | 0.0457 | 0.0284 |
| 189 | 160.5 | 0.0063 | 0.0297 | 0.0272 | 172.6 | 0.0117 | 0.0464 | 0.0288 |
| 190 | 163.3 | 0.0064 | 0.0300 | 0.0276 | 175.7 | 0.0119 | 0.0471 | 0.0292 |
| 191 | 166.2 | 0.0065 | 0.0304 | 0.0280 | 178.8 | 0.0121 | 0.0479 | 0.0296 |
| 192 | 169.1 | 0.0066 | 0.0307 | 0.0284 | 182.0 | 0.0124 | 0.0486 | 0.0300 |
| 193 | 172.0 | 0.0067 | 0.0310 | 0.0287 | 185.2 | 0.0126 | 0.0494 | 0.0304 |

TABLE 148—Continued

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Hypophysis | Suprarenals | Thyroid | Body weight | Hypophysis | Suprarenals | Thyroid |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 194 | 175.0 | 0.0068 | 0.0314 | 0.0291 | 188.5 | 0.0129 | 0.0502 | 0.0308 |
| 195 | 178.1 | 0.0068 | 0.0317 | 0.0295 | 191.9 | 0.0131 | 0.0510 | 0.0312 |
| 196 | 181.2 | 0.0069 | 0.0321 | 0.0299 | 195.3 | 0.0134 | 0.0518 | 0.0317 |
| 197 | 184.3 | 0.0070 | 0.0324 | 0.0303 | 198.7 | 0.0136 | 0.0526 | 0.0321 |
| 198 | 187.5 | 0.0071 | 0.0328 | 0.0307 | 202.2 | 0.0139 | 0.0535 | 0.0325 |
| 199 | 190.8 | 0.0072 | 0.0331 | 0.0311 | 205.8 | 0.0142 | 0.0543 | 0.0330 |
| 200 | 194.1 | 0.0073 | 0.0335 | 0.0315 | 209.4 | 0.0145 | 0.0552 | 0.0334 |
| 201 | 197.4 | 0.0074 | 0.0338 | 0.0319 | 213.1 | 0.0148 | 0.0560 | 0.0339 |
| 202 | 200.8 | 0.0075 | 0.0342 | 0.0323 | 216.8 | 0.0150 | 0.0569 | 0.0343 |
| 203 | 204.3 | 0.0076 | 0.0346 | 0.0328 | 220.7 | 0.0153 | 0.0579 | 0.0348 |
| 204 | 207.8 | 0.0077 | 0.0350 | 0.0332 | 224.5 | 0.0155 | 0.0588 | 0.0352 |
| 205 | 211.4 | 0.0078 | 0.0354 | 0.0336 | 228.4 | 0.0159 | 0.0597 | 0.0357 |
| 206 | 215.0 | 0.0079 | 0.0358 | 0.0341 | 232.4 | 0.0162 | 0.0606 | 0.0362 |
| 207 | 218.7 | 0.0080 | 0.0362 | 0.0345 | 236.5 | 0.0166 | 0.0616 | 0.0367 |
| 208 | 222.5 | 0.0081 | 0.0366 | 0.0350 | 240.6 | 0.0169 | 0.0626 | 0.0372 |
| 209 | 226.3 | 0.0082 | 0.0370 | 0.0355 | 244.8 | 0.0172 | 0.0636 | 0.0377 |
| 210 | 230.2 | 0.0083 | 0.0374 | 0.0359 | 249.1 | 0.0175 | 0.0646 | 0.0382 |
| 211 | 234.1 | 0.0084 | 0.0378 | 0.0364 | 253.4 | 0.0179 | 0.0656 | 0.0387 |
| 212 | 238.1 | 0.0086 | 0.0382 | 0.0369 | 257.8 | 0.0182 | 0.0667 | 0.0392 |
| 213 | 242.2 | 0.0087 | 0.0387 | 0.0374 | 262.3 | 0.0186 | 0.0677 | 0.0398 |
| 214 | 246.3 | 0.0088 | 0.0391 | 0.0379 | 266.9 | 0.0189 | 0.0688 | 0.0403 |
| 215 | 250.5 | 0.0089 | 0.0395 | 0.0384 | 271.5 | 0.0193 | 0.0699 | 0.0408 |
| 216 | 254.7 | 0.0090 | 0.0400 | 0.0389 | 276.2 | 0.0196 | 0.0710 | 0.0414 |
| 217 | 259.1 | 0.0092 | 0.0404 | 0.0394 | 281.0 | 0.0200 | 0.0721 | 0.0420 |
| 218 | 263.5 | 0.0093 | 0.0409 | 0.0399 | 285.8 | 0.0204 | 0.0733 | 0.0425 |
| 219 | 267.9 | 0.0094 | 0.0414 | 0.0404 | 290.8 | 0.0208 | 0.0744 | 0.0431 |
| 220 | 272.5 | 0.0095 | 0.0418 | 0.0410 | 295.8 | 0.0212 | 0.0756 | 0.0437 |
| 221 | 277.1 | 0.0097 | 0.0423 | 0.0415 | 300.9 | 0.0216 | 0.0768 | 0.0443 |
| 222 | 281.8 | 0.0098 | 0.0428 | 0.0421 | 306.1 | 0.0220 | 0.0781 | 0.0449 |
| 223 | 286.5 | 0.0099 | 0.0433 | 0.0426 | 311.3 | 0.0224 | 0.0793 | 0.0455 |
| 224 | 291.4 | 0.0101 | 0.0438 | 0.0432 | 316.7 | 0.0228 | 0.0805 | 0.0461 |
| 225 | 296.3 | 0.0102 | 0.0443 | 0.0437 | 322.1 | 0.0232 | 0.0818 | 0.0467 |
| 226 | 301.3 | 0.0103 | 0.0448 | 0.0443 | 327.7 | 0.0237 | 0.0831 | 0.0474 |
| 227 | 306.4 | 0.0105 | 0.0453 | 0.0449 | 333.3 | 0.0242 | 0.0845 | 0.0480 |
| 228 | 311.5 | 0.0106 | 0.0458 | 0.0455 | 339.0 | 0.0246 | 0.0858 | 0.0486 |
| 229 | 316.8 | 0.0108 | 0.0464 | 0.0461 | 344.8 | 0.0250 | 0.0872 | 0.0493 |
| 230 | 322.1 | 0.0109 | 0.0469 | 0.0467 | 350.7 | 0.0255 | 0.0885 | 0.0500 |

TABLE 148—Concluded

| | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Body weight | Hypophysis | Supra-renals | Thyroid | Body weight | Hypophysis | Supra-renals | Thyroid |
| *mm.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| 231 | 327.5 | 0.0111 | 0.0474 | 0.0473 | 356.7 | 0.0259 | 0.0899 | 0.0507 |
| 232 | 333.0 | 0.0112 | 0.0480 | 0.0480 | 362.8 | 0.0264 | 0.0914 | 0.0513 |
| 233 | 338.6 | 0.0114 | 0.0485 | 0.0486 | 369.0 | 0.0269 | 0.0928 | 0.0520 |
| 234 | 344.3 | 0.0115 | 0.0491 | 0.0493 | 375.3 | 0.0274 | 0.0943 | 0.0527 |
| 235 | 350.0 | 0.0117 | 0.0497 | 0.0499 | 381.7 | 0.0279 | 0.0958 | 0.0535 |
| 236 | 355.9 | 0.0118 | 0.0503 | 0.0506 | 388.2 | 0.0284 | 0.0973 | 0.0542 |
| 237 | 361.9 | 0.0120 | 0.0509 | 0.0512 | 394.9 | 0.0290 | 0.0989 | 0.0549 |
| 238 | 367.9 | 0.0122 | 0.0514 | 0.0519 | 401.6 | 0.0295 | 0.1005 | 0.0557 |
| 239 | 374.1 | 0.0123 | 0.0521 | 0.0526 | 408.4 | 0.0300 | 0.1021 | 0.0564 |
| 240 | 380.3 | 0.0125 | 0.0527 | 0.0533 | 415.4 | 0.0306 | 0.1037 | 0.0572 |
| 241 | 386.6 | 0.0127 | 0.0533 | 0.0540 | 422.4 | 0.0311 | 0.1053 | 0.0580 |
| 242 | 393.1 | 0.0129 | 0.0539 | 0.0548 | 429.6 | 0.0317 | 0.1070 | 0.0588 |
| 243 | 399.6 | 0.0130 | 0.0546 | 0.0555 | 436.9 | 0.0323 | 0.1087 | 0.0596 |
| 244 | 406.3 | 0.0132 | 0.0552 | 0.0562 | 444.3 | 0.0329 | 0.1105 | 0.0604 |
| 245 | 413.1 | 0.0134 | 0.0559 | 0.0570 | 451.9 | 0.0335 | 0.1122 | 0.0613 |
| 246 | 419.9 | 0.0136 | 0.0565 | 0.0577 | 459.5 | 0.0341 | 0.1140 | 0.0621 |
| 247 | 426.9 | 0.0138 | 0.0572 | 0.0585 | 467.3 | 0.0347 | 0.1158 | 0.0630 |
| 248 | 434.0 | 0.0140 | 0.0579 | 0.0593 | 475.2 | 0.0353 | 0.1177 | 0.0638 |
| 249 | 441.2 | 0.0142 | 0.0586 | 0.0601 | 483.3 | 0.0359 | 0.1196 | 0.0647 |
| 250 | 448.5 | 0.0144 | 0.0593 | 0.0609 | 491.5 | 0.0366 | 0.1251 | 0.0656 |

## *Weight of other organs*

*Prostate gland.* The prostate gland is invested by a fibrous coat which contains a large amount of lipoid like substance. All non-glandular structures can be easily separated from the glandular tissue by pulling off this fibrous coat. The glandular tissue alone was weighed. (Hatai MS). Table 149.

TABLE 149

*Weights of prostate gland, lens (2) and pineal gland on body weight. (Hatai '23, MS.). Males 182 cases—Females 107 cases, in groups of six or more*

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body weight | Age | Prostate | Lens (2) | Pineal | Pineal | Lens (2) | Age | Body weight |
| *grams* | *days* | *mgms.* | *mgms.* | *mgms.* | *mgms.* | *mgms.* | *days* | *grams* |
| 4.1 | 0 | 0.5 | 5.2 | 0.5 | 0.3 | 4.6 | 0 | 4.1 |
| 5.3 | 0 | 0.5 | 6.1 | 0.4 | — | — | — | — |
| 7.1 | 3 | 1.5 | 10.7 | 0.4 | 0.5 | 9.2 | 3 | 7.1 |
| 13.1 | 12 | 3.1 | 19.8 | 0.6 | 0.5 | 20.3 | 12 | 13.6 |
| 21.0 | 14 | 3.7 | 22.7 | 0.6 | — | — | — | — |
| 25.7 | 25 | 11.5 | 33.9 | 0.6 | 0.7 | 32.8 | 27 | 26.3 |
| 32.5 | 29 | 10.7 | 36.2 | 0.7 | 0.8 | 41.7 | 41 | 45.1 |
| 52.6 | 48 | 19.1 | 48.5 | 0.8 | 0.8 | 46.5 | 47 | 55.4 |
| 65.5 | 46 | 21.9 | 49.1 | 1.0 | 0.9 | 46.0 | 45 | 65.8 |
| 75.0 | 48 | 25.8 | 50.7 | 1.0 | — | — | — | — |
| 87.4 | 55 | 33.1 | 42.3 | 1.0 | 1.0 | 53.3 | 51 | 76.3 |
| 102.7 | 74 | 62.9 | 61.6 | 1.0 | 0.9 | 74.3 | 71 | 104.9 |
| 124.4 | 72 | 72.1 | 64.6 | 0.8 | 1.0 | 67.5 | 68 | 116.5 |
| 135.3 | 70 | 88.8 | 63.3 | 1.1 | 0.9 | 64.7 | 70 | 130.3 |
| 144.9 | 99 | 129.8 | 69.2 | 1.1 | 1.2 | 71.9 | 92 | 151.1 |
| 155.7 | 118 | 154.2 | 70.5 | 1.1 | — | — | — | — |
| 166.5 | 79 | 146.1 | 57.6 | 1.4 | — | — | — | — |
| 183.1 | 125 | 194.7 | 83.2 | 1.1 | — | — | — | — |
| 189.7 | 92 | 211.2 | 77.0 | 1.5 | — | — | — | — |
| 200.2 | 77 | 162.2 | 64.5 | 1.5 | — | — | — | — |
| 223.2 | 179 | 265.9 | 73.9 | 1.6 | — | — | — | — |
| 262.5 | 239 | 447.7 | — | 1.5 | — | — | — | — |
| 266.4 | 248 | 392.6 | 102.5 | 1.6 | — | — | — | — |
| 295.5 | 363 | 369.9 | 114.3 | 1.4 | 1.4 | 106.4 | 393 | 187.4 |
| 350.8 | 460 | 541.9 | 119.3 | 1.4 | 1.3 | 104.5 | 335 | 205.4 |
| 394.5 | 503 | 660.8 | 108.6 | 1.1 | 1.3 | 114.9 | 433 | 229.6 |
| 460.8 | 664 | 574.4 | 130.3 | 1.6 | 0.9 | 92.7 | 654 | 339.7 |

TABLE 150

*Weights of ovaries, tubes, uterus and vagina—on body weight and age—observed values (Osterud, MS.)*

| BODY WEIGHT | AGE | BODY LENGTH | ABSOLUTE WEIGHTS OF | | | |
|---|---|---|---|---|---|---|
| | | | Ovaries | Tubes | Uterus | Vagina |
| *grams* | *days* | *mm.* | *grams* | *grams* | *grams* | *grams* |
| 4.8 | 0 | 49 | 0.0008 | 0.0008 | 0.0014 | 0.0009 |
| 7.6 | 4 | 57 | 0.0009 | 0.0008 | 0.0028 | 0.0014 |
| 12.3 | 9 | 71 | 0.0014 | 0.0015 | 0.0060 | 0.0030 |
| 18.1 | 15 | 81 | 0.0026 | 0.0025 | 0.0127 | 0.0074 |
| 24.4 | 19 | 93 | 0.0052 | 0.0034 | 0.0196 | 0.0127 |
| 30.0 | 26 | 100 | 0.0092 | 0.0044 | 0.0206 | 0.0169 |
| 35.0 | 33 | 109 | 0.0145 | 0.0039 | 0.0177 | 0.0227 |
| 43.0 | 33 | 116 | 0.0102 | 0.0042 | 0.0195 | 0.0191 |
| 51.3 | 42 | 123 | 0.0104 | 0.0051 | 0.0294 | 0.0247 |
| 59.1 | 47 | 130 | 0.0123 | 0.0054 | 0.0348 | 0.0250 |
| 65.7 | 51 | 132 | 0.0135 | 0.0064 | 0.0410 | 0.0363 |
| 72.3 | 58 | 136 | 0.0135 | 0.0074 | 0.0593 | 0.0434 |
| 79.5 | 61 | 141 | 0.0168 | 0.0093 | 0.1182 | 0.0629 |
| 87.2 | 67 | 147 | 0.0185 | 0.0097 | 0.1149 | 0.0603 |
| 99.2 | 70 | 156 | 0.0297 | 0.0124 | 0.1615 | 0.0878 |
| 114.0 | 81 | 162 | 0.0435 | 0.0139 | 0.1938 | 0.0953 |
| 133.0 | 94 | 170 | 0.0470 | 0.0162 | 0.2881 | 0.1044 |
| 156.0 | 131 | 181 | 0.0411 | 0.0155 | 0.3390 | 0.0972 |
| 185.0 | 165 | 188 | 0.0635 | 0.0200 | 0.4206 | 0.1322 |
| 207.0 | 171 | 193 | 0.0564 | 0.0150 | 0.2994 | 0.1137 |
| 263.0 | 276 | 214 | 0.0593 | 0.0218 | 0.2880 | 0.1165 |

*Lens.* The eyeballs are removed as usual: carefully cut with small sharp scissors and the lens gently pressed out. The lens is surrounded by aqueous humor which is removed by lightly rolling lens over filter paper. Too much rolling is dangerous because the lens surface can be injured. The lens thus freed from adherent liquid is placed with its mate in a previously weighed bottle and weighed. The growth of the lens is more precocious and relatively much greater than that of the eyeball. (Hatai MS). (Table 149.)

*Pineal gland.* After removal of the overlying bone and pushing aside the vessels, the pineal is picked up with a very fine forceps and the peduncles severed. On account of its small size and the effect of slight differences in the adherent moisture, the absolute weights for this organ are the least trustworthy of any. As compared with the other endocrine glands, the growth of the pineal is very small. (Hatai MS). (Table 149.)

*Weights of parts of the female reproductive tract (Osterud MS).* This study was based on 155 females; of these 125 were virgin and the remainder had given birth to one litter. Under precautions to prevent drying, the ovaries and tubes were isolated by severing the tubes close to the tip of the uterine horn.

These were dissected apart, and separated from extraneous tissue. The uterus and vagina were similarly isolated and then were separated by transection of the latter in a plane just missing the tip of the cervix. The weights were taken in closed bottles. The values obtained are given in table 150.

When the data on the weight of the ovaries are compared with those in table 146 it is seen that they tend to run high, especially for the heavy body weights. This difference would suggest the formation of a larger number of corpora in the series examined by Osterud.

9. *Weight of thymus on age: Table 151. On length: table 152.*

TABLE 151

*Giving the weight of the thymus in grams—sexes combined—for the first 400 days of life. See Chart 48*

| AGE IN DAYS | WEIGHT OF THYMUS | AGE IN DAYS | WEIGHT OF THYMUS | AGE IN DAYS | WEIGHT OF THYMUS | AGE IN DAYS | WEIGHT OF THYMUS |
|---|---|---|---|---|---|---|---|
| B. | 0.008 | | | | | | |
| 1 | 0.008 | 11 | 0.026 | 21 | 0.048 | 31 | 0.083 |
| 2 | 0.010 | 12 | 0.028 | 22 | 0.051 | 32 | 0.087 |
| 3 | 0.012 | 13 | 0.029 | 23 | 0.054 | 33 | 0.091 |
| 4 | 0.015 | 14 | 0.031 | 24 | 0.057 | 34 | 0.095 |
| 5 | 0.017 | 15 | 0.034 | 25 | 0.061 | 35 | 0.100 |
| 6 | 0.018 | 16 | 0.036 | 26 | 0.064 | 36 | 0.104 |
| 7 | 0.020 | 17 | 0.038 | 27 | 0.067 | 37 | 0.109 |
| 8 | 0.021 | 18 | 0.040 | 28 | 0.071 | 38 | 0.114 |
| 9 | 0.022 | 19 | 0.043 | 29 | 0.075 | 39 | 0.118 |
| 10 | 0.024 | 20 | 0.046 | 30 | 0.079 | 40 | 0.123 |

TABLE 151—*Concluded*

| AGE IN DAYS | WEIGHT OF THYMUS | AGE IN DAYS | WEIGHT OF THYMUS | AGE IN DAYS | WEIGHT OF THYMUS | AGE IN DAYS | WEIGHT OF THYMUS |
|---|---|---|---|---|---|---|---|
| 41 | 0.128 | 76 | 0.285 | 111 | 0.252 | 146 | 0.215 |
| 42 | 0.133 | 77 | 0.286 | 112 | 0.251 | 147 | 0.214 |
| 43 | 0.139 | 78 | 0.288 | 113 | 0.250 | 148 | 0.213 |
| 44 | 0.144 | 79 | 0.289 | 114 | 0.249 | 149 | 0.212 |
| 45 | 0.149 | 80 | 0.290 | 115 | 0.247 | 150 | 0.211 |
| 46 | 0.154 | | | 116 | 0.246 | | |
| 47 | 0.160 | 81 | 0.290 | 117 | 0.245 | 160 | 0.201 |
| 48 | 0.165 | 82 | 0.291 | 118 | 0.244 | 170 | 0.191 |
| 49 | 0.171 | 83 | 0.291 | 119 | 0.243 | 180 | 0.182 |
| 50 | 0.176 | 84 | 0.290 | 120 | 0.242 | 190 | 0.172 |
| | | 85 | 0.290 | | | 200 | 0.164 |
| 51 | 0.181 | 86 | 0.289 | 121 | 0.241 | | |
| 52 | 0.187 | 87 | 0.288 | 122 | 0.240 | 210 | 0.155 |
| 53 | 0.192 | 88 | 0.287 | 123 | 0.239 | 220 | 0.147 |
| 54 | 0.198 | 89 | 0.285 | 124 | 0.238 | 230 | 0.138 |
| 55 | 0.203 | 90 | 0.283 | 125 | 0.237 | 240 | 0.130 |
| 56 | 0.208 | | | 126 | 0.236 | 250 | 0.123 |
| 57 | 0.213 | 91 | 0.281 | 127 | 0.234 | | |
| 58 | 0.218 | 92 | 0.278 | 128 | 0.233 | 260 | 0.115 |
| 59 | 0.224 | 93 | 0.276 | 129 | 0.232 | 270 | 0.108 |
| 60 | 0.229 | 94 | 0.273 | 130 | 0.231 | 280 | 0.102 |
| | | 95 | 0.270 | | | 290 | 0.095 |
| 61 | 0.233 | 96 | 0.269 | 131 | 0.230 | 300 | 0.089 |
| 62 | 0.238 | 97 | 0.268 | 132 | 0.229 | | |
| 63 | 0.243 | 98 | 0.266 | 133 | 0.228 | 310 | 0.082 |
| 64 | 0.247 | 99 | 0.265 | 134 | 0.227 | 320 | 0.077 |
| 65 | 0.251 | 100 | 0.264 | 135 | 0.226 | 330 | 0.071 |
| 66 | 0.255 | | | 136 | 0.225 | 340 | 0.066 |
| 67 | 0.259 | 101 | 0.263 | 137 | 0.224 | 350 | 0.061 |
| 68 | 0.263 | 102 | 0.262 | 138 | 0.223 | | |
| 69 | 0.267 | 103 | 0.261 | 139 | 0.222 | 360 | 0.056 |
| 70 | 0.270 | 104 | 0.260 | 140 | 0.221 | 370 | 0.051 |
| | | 105 | 0.259 | | | 380 | 0.047 |
| 71 | 0.273 | 106 | 0.257 | 141 | 0.220 | 390 | 0.043 |
| 72 | 0.276 | 107 | 0.256 | 142 | 0.219 | 400 | 0.039 |
| 73 | 0.278 | 108 | 0.255 | 143 | 0.218 | | |
| 74 | 0.281 | 109 | 0.254 | 144 | 0.217 | | |
| 75 | 0.283 | 110 | 0.253 | 145 | 0.216 | | |

TABLE 152

*Weights of thymus for each sex and at each millimeter of body length*

| | MALES | | FEMALES | |
|---|---|---|---|---|
| Body length | Body weight | Weight of thymus | Body weight | Weight of thymus |
| *mm.* | *grams* | *grams* | *grams* | *grams* |
| 47 | 4.9 | 0.007 | 4.7 | 0.007 |
| 48 | 4.9 | 0.007 | 4.7 | 0.007 |
| 49 | 5.0 | 0.007 | 4.9 | 0.007 |
| 50 | 5.1 | 0.007 | 5.0 | 0.008 |
| 51 | 5.2 | 0.008 | 5.1 | 0.008 |
| 52 | 5.3 | 0.008 | 5.3 | 0.008 |
| 53 | 5.4 | 0.008 | 5.5 | 0.008 |
| 54 | 5.6 | 0.008 | 5.8 | 0.010 |
| 55 | 5.8 | 0.010 | 6.2 | 0.012 |
| 56 | 6.1 | 0.011 | 6.5 | 0.015 |
| 57 | 6.4 | 0.012 | 6.9 | 0.015 |
| 58 | 6.8 | 0.015 | 7.2 | 0.016 |
| 59 | 7.1 | 0.015 | 7.6 | 0.017 |
| 60 | 7.5 | 0.016 | 8.0 | 0.017 |
| 61 | 7.9 | 0.016 | 8.4 | 0.018 |
| 62 | 8.2 | 0.017 | 8.7 | 0.020 |
| 63 | 8.6 | 0.017 | 9.1 | 0.020 |
| 64 | 9.0 | 0.018 | 9.5 | 0.020 |
| 65 | 9.4 | 0.020 | 9.9 | 0.021 |
| 66 | 9.8 | 0.020 | 10.3 | 0.021 |
| 67 | 10.1 | 0.021 | 10.8 | 0.021 |
| 68 | 10.6 | 0.021 | 11.2 | 0.022 |
| 69 | 11.0 | 0.022 | 11.6 | 0.023 |
| 70 | 11.4 | 0.022 | 12.0 | 0.024 |
| 71 | 11.8 | 0.023 | 12.5 | 0.025 |
| 72 | 12.2 | 0.024 | 12.9 | 0.026 |
| 73 | 12.7 | 0.025 | 13.4 | 0.026 |
| 74 | 13.1 | 0.026 | 13.9 | 0.027 |
| 75 | 13.6 | 0.027 | 14.3 | 0.027 |
| 76 | 14.0 | 0.028 | 14.8 | 0.028 |
| 77 | 14.5 | 0.028 | 15.3 | 0.028 |
| 78 | 15.0 | 0.029 | 15.8 | 0.031 |
| 79 | 15.4 | 0.031 | 16.3 | 0.032 |
| 80 | 15.9 | 0.032 | 16.8 | 0.033 |
| 81 | 16.4 | 0.034 | 17.3 | 0.034 |
| 82 | 16.9 | 0.036 | 17.9 | 0.034 |

TABLE 152—*Concluded*

| MALES | | | FEMALES | |
|---|---|---|---|---|
| Body length | Body weight | Weight of thymus | Body weight | Weight of thymus |
| *mm.* | *grams* | *grams* | *grams* | *grams* |
| 83 | 17.4 | 0.038 | 18.4 | 0.035 |
| 84 | 18.0 | 0.039 | 19.0 | 0.037 |
| 85 | 18.5 | 0.040 | 19.5 | 0.038 |
| 86 | 19.0 | 0.041 | 20.1 | 0.040 |
| 87 | 19.6 | 0.043 | 20.7 | 0.043 |
| 88 | 20.1 | 0.044 | 21.2 | 0.044 |
| 89 | 20.7 | 0.046 | 21.8 | 0.046 |
| 90 | 21.3 | 0.048 | 22.4 | 0.048 |
| 91 | 21.9 | 0.050 | 23.1 | 0.050 |
| 92 | 22.4 | 0.052 | 23.7 | 0.052 |
| 93 | 23.0 | 0.054 | 24.3 | 0.054 |
| 94 | 23.7 | 0.056 | 25.0 | 0.055 |
| 95 | 24.3 | 0.057 | 25.6 | 0.057 |
| 96 | 24.9 | 0.059 | 26.3 | 0.059 |
| 97 | 25.6 | 0.061 | 27.0 | 0.060 |
| 98 | 26.2 | 0.063 | 27.7 | 0.061 |
| 99 | 26.9 | 0.065 | 28.4 | 0.063 |
| 100 | 27.5 | 0.067 | 29.1 | 0.065 |
| 110 | 34.9 | 0.095 | 36.9 | 0.099 |
| 120 | 43.5 | 0.127 | 46.0 | 0.133 |
| 130 | 53.6 | 0.159 | 56.8 | 0.171 |
| 140 | 65.4 | 0.196 | 69.5 | 0.203 |
| 150 | 79.3 | 0.229 | 84.4 | 0.247 |
| 160 | 95.6 | 0.253 | 102.0 | 0.273 |
| 170 | 114.7 | 0.278 | 122.7 | 0.291 |
| 180 | 137.0 | 0.291 | 147.1 | 0.266 |
| 190 | 163.3 | 0.266 | 175.7 | 0.232 |
| 196 | 181.2 | 0.251 | 195.3 | 0.171 |
| 200 | 194.1 | 0.241 | | |
| 210 | 230.2 | 0.197 | | |
| 219 | 267.9 | 0.118 | | |

10. *Weights of viscera.* Using the data in tables 145–148 the total weight of the viscera comprising the heart, hypophysis, intestines, kidneys (2), liver, lungs (2), pancreas, spleen, stomach, submaxillaries (2), suprarenals (2) and thyroid has been determined for a series of body weights—table 153.

*Relative percentage weights of viscera and organs (Donaldson, '23).* All viscera (12).[9] See list, table 153.

From table 153 we may compute the percentage weights of all the (12) viscera for a series of selected body weights. The data are entered in table 154.

When the percentage weight at birth is taken as unity, the relative percentage values at the selected body weights may be determined. These for all the viscera are entered in table 155 and the corresponding graphs are given in chart 49–1.[10]

The graphs show a maximum relative value at 25 grams, while at 400 grams this value is about that found at birth. Whether the sex difference here shown is significant is a question.

*Individual viscera and other organs (20).* Proceeding in the same manner as in the case of all the viscera, the relative percentage weights have been determined separately for each of the twenty organs at each of the selected body weights, and these are entered in table 156.

When the relative percentage weight shows a maximum before 25 grams of body weight, this is also entered. The organs have been listed in table 156 first, in the order of the increasing final relative weight (males) for those organs which do not show a post-natal maximum, and second, in the order of the body

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[9] The term "viscera" as generally used, is one of convenience, and it is desirable to note that the list of organs here used as viscera differs from that of Jackson and Lowrey ('12) by containing the submaxillaries and hypophysis and by lacking the brain, spinal cord, eyeballs, thymus and gonads.

The alimentary tract of Jackson and Lowrey includes the stomach, pancreas and intestinal tract. This list differs from theirs in naming these parts separately. This list of organs differs also from that used in table 73 (The Rat, '15) in containing the submaxillaries and in lacking the gonads and the thymus, while the alimentary tract, as given in table 73, is equivalent to the pancreas and intestinal tract combined. The data for the weight of the intestinal tract are still in manuscript form.

[10] In this and the subsequent charts of this series the scale on the base line changes at 50 grams; the entry for which is put in twice. Before 50 grams one division has the value of 5 grams—after 50 grams, the value of 20 grams.

TABLE 153

*Weight of viscera: Includes Heart, Hypophysis, Intestines, Kidneys (2), Liver, Lungs (2), Pancreas, Spleen, Stomach, Submaxillaries (2), Suprarenals (2), Thyroid.*

| MALES | | | | FEMALES | | |
|---|---|---|---|---|---|---|
| Body length | Body weight | Weight of viscera | Percentage on body weight | Percentage on body weight | Weight of viscera | Body weight |
| *mm.* | *grams* | *grams* | | | *grams* | *grams* |
| 47 | 4.9 | 0.531 | 10.8 | 11.0 | 0.518 | 4.7 |
| 50 | 5.1 | 0.563 | 11.0 | 11.3 | 0.564 | 5.0 |
| 55 | 5.8 | 0.664 | 11.5 | 11.6 | 0.718 | 6.2 |
| 60 | 7.5 | 0.892 | 11.9 | 11.9 | 0.955 | 8.0 |
| 65 | 9.4 | 1.143 | 12.2 | 12.2 | 1.212 | 9.9 |
| 70 | 11.4 | 1.640 | 14.4 | 15.1 | 1.812 | 12.0 |
| 75 | 13.6 | 2.249 | 16.5 | 17.0 | 2.433 | 14.3 |
| 80 | 15.9 | 2.833 | 17.8 | 18.2 | 3.063 | 16.8 |
| 85 | 18.5 | 3.456 | 18.7 | 18.9 | 3.676 | 19.5 |
| 90 | 21.3 | 4.059 | 19.0 | 19.2 | 4.299 | 22.4 |
| 95 | 24.3 | 4.673 | 19.2 | 19.2 | 4.930 | 25.6 |
| 100 | 27.5 | 5.291 | 19.2 | 19.2 | 5.583 | 29.1 |
| 105 | 31.1 | 5.936 | 19.1 | 19.0 | 6.232 | 32.8 |
| 110 | 34.9 | 6.584 | 18.8 | 18.7 | 6.904 | 36.9 |
| 115 | 39.0 | 7.246 | 18.6 | 18.4 | 7.604 | 41.3 |
| 120 | 43.5 | 7.927 | 18.2 | 18.0 | 8.297 | 46.0 |
| 125 | 48.3 | 8.641 | 17.9 | 17.7 | 9.039 | 51.2 |
| 130 | 53.6 | 9.364 | 17.5 | 17.3 | 9.801 | 56.8 |
| 135 | 59.3 | 10.135 | 17.1 | 16.9 | 10.601 | 62.9 |
| 140 | 65.4 | 10.924 | 16.7 | 16.4 | 11.428 | 69.5 |
| 145 | 72.1 | 11.743 | 16.3 | 16.0 | 12.308 | 76.7 |
| 150 | 79.3 | 12.620 | 15.9 | 15.6 | 13.207 | 84.4 |
| 155 | 87.1 | 13.520 | 15.5 | 15.3 | 14.170 | 92.9 |
| 160 | 95.6 | 14.462 | 15.1 | 14.9 | 15.165 | 102.0 |
| 165 | 104.7 | 15.453 | 14.8 | 14.5 | 16.225 | 111.9 |
| 170 | 114.7 | 16.513 | 14.4 | 14.2 | 17.362 | 122.7 |
| 175 | 125.4 | 17.614 | 14.0 | 13.8 | 18.546 | 134.4 |
| 180 | 137.0 | 18.795 | 13.7 | 13.4 | 19.797 | 147.1 |
| 185 | 149.6 | 20.033 | 13.4 | 13.1 | 21.139 | 160.8 |
| 190 | 163.3 | 21.361 | 13.1 | 12.8 | 22.562 | 175.7 |
| 195 | 178.1 | 22.759 | 12.8 | 12.5 | 24.070 | 191.9 |
| 200 | 194.1 | 24.241 | 12.5 | 12.3 | 25.683 | 209.4 |
| 205 | 211.4 | 25.835 | 12.2 | 12.0 | 27.403 | 228.4 |
| 210 | 230.2 | 27.529 | 12.0 | 11.7 | 29.246 | 249.1 |
| 215 | 250.5 | 29.330 | 11.7 | 11.5 | 31.210 | 271.5 |
| 220 | 272.5 | 31.252 | 11.5 | 11.3 | 33.321 | 295.8 |
| 225 | 296.3 | 33.248 | 11.2 | 11.0 | 35.559 | 322.1 |
| 230 | 322.1 | 35.513 | 11.0 | 10.8 | 37.981 | 350.7 |
| 235 | 350.0 | 37.874 | 10.8 | 10.6 | 40.579 | 381.7 |
| 240 | 380.3 | 40.413 | 10.6 | 10.4 | 43.385 | 415.4 |
| 245 | 413.1 | 43.125 | 10.4 | 10.3 | 46.375 | 451.9 |
| 250 | 448.5 | 46.029 | 10.3 | 10.1 | 49.604 | 491.5 |

weights at which the post-natal maximum appears. The graph for each organ appears in the corresponding chart (chart 49, nos. 2–21). Where the graphs for the two sexes are similar, only that for the male has been drawn.

TABLE 154

*Weight of viscera (12)*

| BODY WEIGHT | MALES | | FEMALES | |
|---|---|---|---|---|
| | Weight of viscera (12) | Percentage on body weight | Percentage on body weight | Weight of viscera (12) |
| *grams* | *grams* | | | *grams* |
| 4.9 | 0.534 | 10.89 | 11.12 | 0.545 |
| 25.0 | 4.808 | 19.23 | 19.24 | 4.811 |
| 50.0 | 8.872 | 17.74 | 17.73 | 8.865 |
| 100.0 | 14.942 | 14.94 | 14.94 | 14.944 |
| 200.0 | 24.784 | 12.39 | 12.41 | 24.816 |
| 300.0 | 33.574 | 11.19 | 11.23 | 33.678 |
| 400.0 | 42.050 | 10.51 | 10.76 | 43.059 |

TABLE 155

*Relative percentage weight of viscera*

| BODY WEIGHT | MALES | FEMALES |
|---|---|---|
| | Relative per cent | Relative per cent |
| *grams* | | |
| 4.9 | 1.00 | 1.00 |
| 25.0 | 1.76 | 1.68 |
| 50.0 | 1.64 | 1.55 |
| 100.0 | 1.38 | 1.31 |
| 200.0 | 1.14 | 1.08 |
| 300.0 | 1.03 | 0.98 |
| 400.0 | 0.97 | 0.92 |

By the use of the data in these tables and charts it is possible to obtain a picture of the organ composition of the rat at various body weights. In this series the body weights up to 250 grams are normal for age—as given in table 157.

For the details of the relations the original paper (Donaldson, '23) should be consulted, but it may be pointed out here that the phase of rapid growth in an organ coincides with the coming of

TABLE 156

*Relative percentage weight of organs on body weight*

| BODY WEIGHT | LUNGS | | HYPOPHYSIS | | THYROID | | BLOOD | | SUBMAXILLARIES | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females | Males | Females | Males | Females |
| *grams* | | | | | | | | | | |
| 4.7–5.1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 6.2 | — | — | — | — | — | — | — | — | — | 1.03 |
| 25.0 | 0.62 | 0.57 | 0.78 | 0.71 | 0.87 | 0.90 | 0.84 | 0.87 | 0.85 | 0.85 |
| 50.0 | 0.50 | 0.47 | 0.61 | 0.57 | 0.76 | 0.79 | 0.79 | 0.81 | 0.74 | 0.74 |
| 100.0 | 0.42 | 0.39 | 0.50 | 0.62 | 0.66 | 0.68 | 0.73 | 0.75 | 0.62 | 0.62 |
| 200.0 | 0.37 | 0.35 | 0.41 | 0.69 | 0.56 | 0.58 | 0.67 | 0.75 | 0.56 | 0.56 |
| 300.0 | 0.35 | 0.33 | 0.38 | 0.71 | 0.51 | 0.53 | 0.63 | 0.72 | 0.53 | 0.53 |
| 400.0 | 0.34 | 0.32 | 0.36 | 0.73 | 0.48 | 0.50 | 0.62 | 0.70 | 0.50 | 0.50 |

| BODY WEIGHT | EYEBALLS | | KIDNEYS | | HEART | | BRAIN | | SPINAL CORD | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.7–4.9 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 7.5 | 1.08 | — | 1.59 | | | | | | | |
| 8.0 | — | 1.07 | — | — | — | 1.09 | | | | |
| 9.4 | — | — | — | — | 1.11 | | | | | |
| 9.9 | — | — | — | 1.56 | | | | | | |
| 11.4 | — | — | — | — | — | — | 1.52 | — | 1.15 | |
| 12.0 | — | — | — | — | — | — | — | 1.58 | — | 1.13 |
| 25.0 | 0.73 | 0.70 | 1.38 | 1.34 | 1.03 | 1.00 | 1.09 | 1.11 | 1.06 | 1.03 |
| 50.0 | 0.49 | 0.50 | 1.17 | 1.12 | 0.89 | 0.88 | 0.65 | 0.65 | 0.85 | 0.83 |
| 100.0 | 0.34 | 0.33 | 1.01 | 0.97 | 0.76 | 0.73 | 0.36 | 0.34 | 0.62 | 0.60 |
| 200.0 | 0.24 | 0.23 | 0.91 | 0.88 | 0.64 | 0.63 | 0.20 | 0.20 | 0.43 | 0.42 |
| 300.0 | 0.19 | 0.18 | 0.87 | 0.84 | 0.59 | 0.58 | 0.14 | 0.14 | 0.34 | 0.33 |
| 400.0 | 0.15 | 0.15 | 0.85 | 0.82 | 0.56 | 0.55 | 0.11 | 0.11 | 0.27 | 0.26 |

| BODY WEIGHT | PANCREAS | | SPLEEN | | SUPRARENALS | | LIVER | | VISCERA | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.7–5.1 | — | — | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 5.8 | — | — | — | — | 1.10 | | | | | |
| 6.2 | — | — | — | — | — | 1.14 | | | | |
| 11.4 | 1.00 | | | | | | | | | |
| 12.0 | — | 1.00 | | | | | | | | |
| 15.9 | 1.18 | | | | | | | | | |
| 16.8 | — | 1.09 | — | 1.88 | | | | | | |
| 18.5 | — | — | 1.80 | | | | | | | |
| 25.0 | 1.08 | 1.04 | 1.72 | 1.82 | 1.15 | 1.11 | 1.81 | 1.81 | 1.76 | 1.68 |
| 50.0 | 0.85 | 0.90 | 1.67 | 1.76 | 0.89 | 0.97 | 1.67 | 1.66 | 1.64 | 1.55 |
| 100.0 | 0.70 | 0.73 | 1.56 | 1.65 | 0.67 | 0.85 | 1.41 | 1.41 | 1.38 | 1.31 |
| 200.0 | 0.60 | 0.61 | 1.50 | 1.59 | 0.52 | 0.78 | 1.17 | 1.17 | 1.14 | 1.08 |
| 300.0 | 0.56 | 0.55 | 1.44 | 1.53 | 0.45 | 0.75 | 1.06 | 1.06 | 1.03 | 0.98 |
| 400.0 | 0.53 | 0.52 | 1.44 | 1.53 | 0.41 | 0.74 | 0.99 | 0.99 | 0.97 | 0.92 |

TABLE 156—*Concluded*

| BODY WEIGHT | INTESTINAL TRACT | | STOMACH | | THYMUS | | GONADS | | EPIDIDYMIDES |
|---|---|---|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females | Testes | Ovaries | Males |
| *grams* | | | | | | | | | |
| 4.7–4.9 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 7.5 | — | — | — | — | 1.50 | | | | |
| 8.0 | — | — | — | — | — | — | — | 3.00 | |
| 9.9 | — | — | — | — | — | 1.57 | | | |
| 11.4 | — | — | — | — | 1.36 | — | 5.75 | — | 0.78 |
| 14.3 | — | — | — | — | — | 1.36 | | | |
| 15.9 | — | — | — | — | — | — | 5.38 | | |
| 25.0 | 4.27 | 3.77 | 1.43 | 1.41 | 1.68 | 1.57 | 6.08 | 2.19 | 0.90 |
| 29.1 | — | 3.81 | | | | | | | |
| 31.1 | 4.34 | | | | | | | | |
| 34.9 | — | — | 1.56 | | | | | | |
| 36.9 | — | — | — | 1.53 | | | | | |
| 50.0 | 4.13 | 3.61 | 1.50 | 1.49 | 2.10 | 2.10 | 9.96 | 2.00 | 1.33 |
| 53.6 | — | — | — | — | 2.14 | | | | |
| 56.8 | — | — | — | — | — | 2.14 | | | |
| 62.9 | — | — | — | — | — | — | — | 1.00 | |
| 100.0 | 3.46 | 3.08 | 1.23 | 1.22 | 1.86 | 1.92 | 16.25 | 3.00 | 2.55 |
| 122.7 | — | — | — | — | — | — | — | 4.00 | |
| 178.0 | — | — | — | — | — | — | — | — | 3.67 |
| 200.0 | 2.79 | 2.44 | 0.94 | 0.92 | 0.84 | 0.57 | 13.58 | 1.95 | 3.63 |
| 300.0 | 2.46 | 2.16 | 0.78 | 0.79 | — | — | 11.18 | 2.00 | 3.22 |
| 400.0 | 2.26 | 1.98 | 0.71 | 0.70 | — | — | 9.58 | 1.00 | 2.71 |

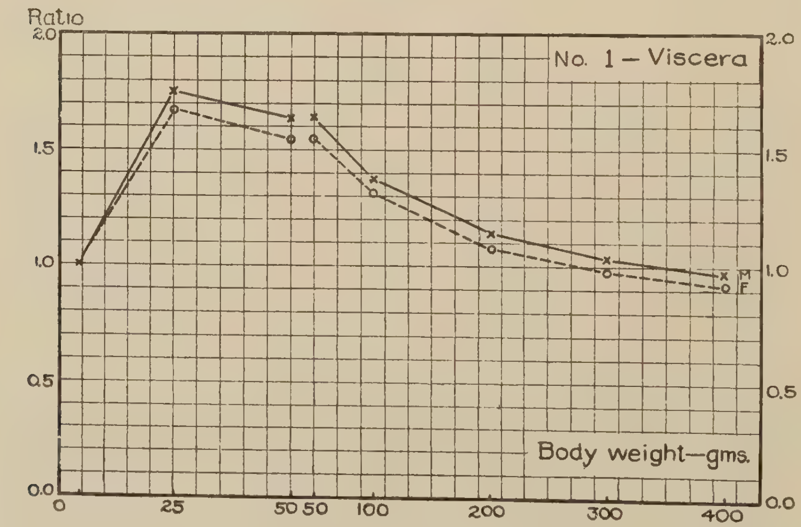


Chart 49—no. 1. Showing the relative percentage values for the weight of the viscera at a series of selected body weights. x————x, males; o-----------o, females. Table 155 (12 organs).

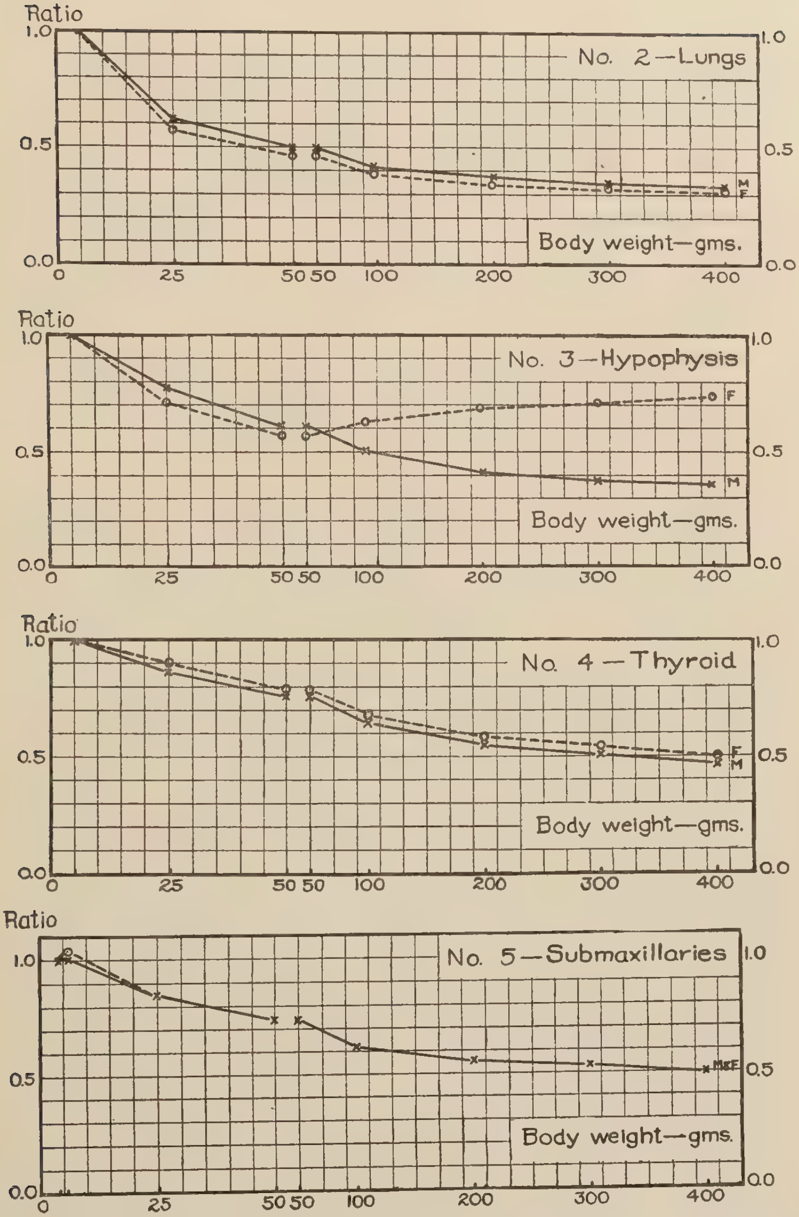
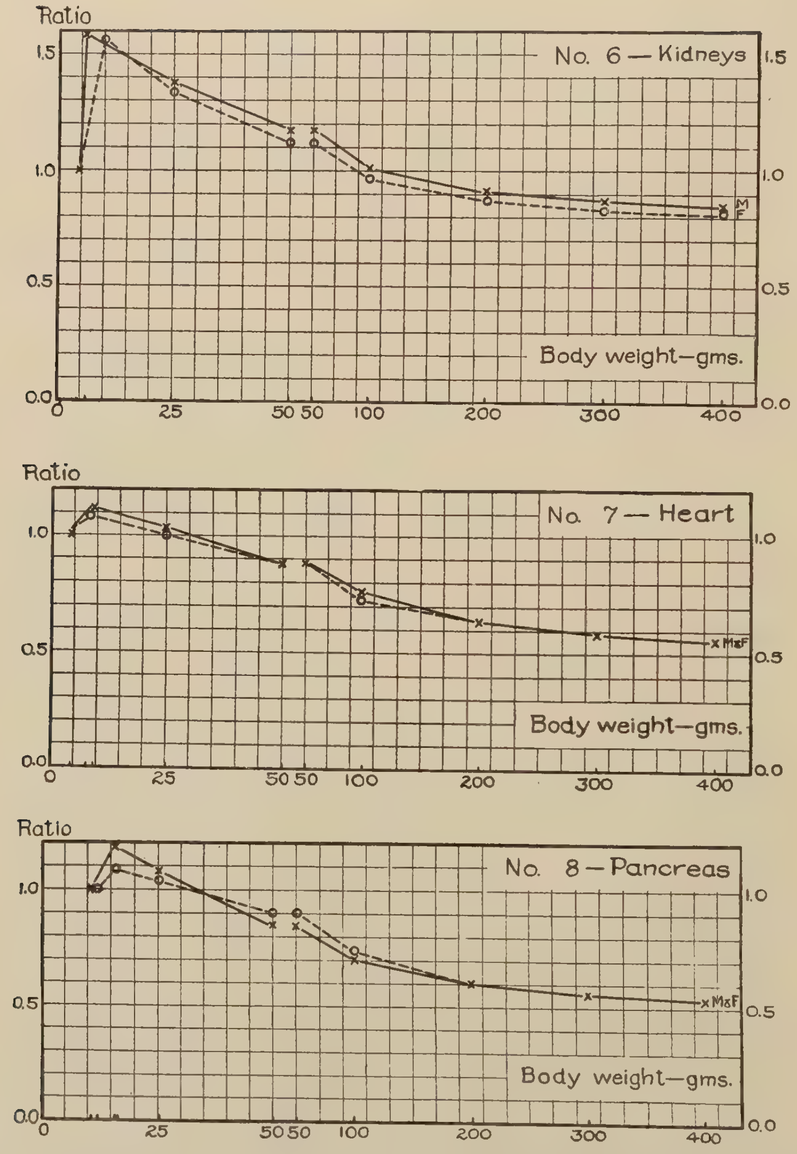
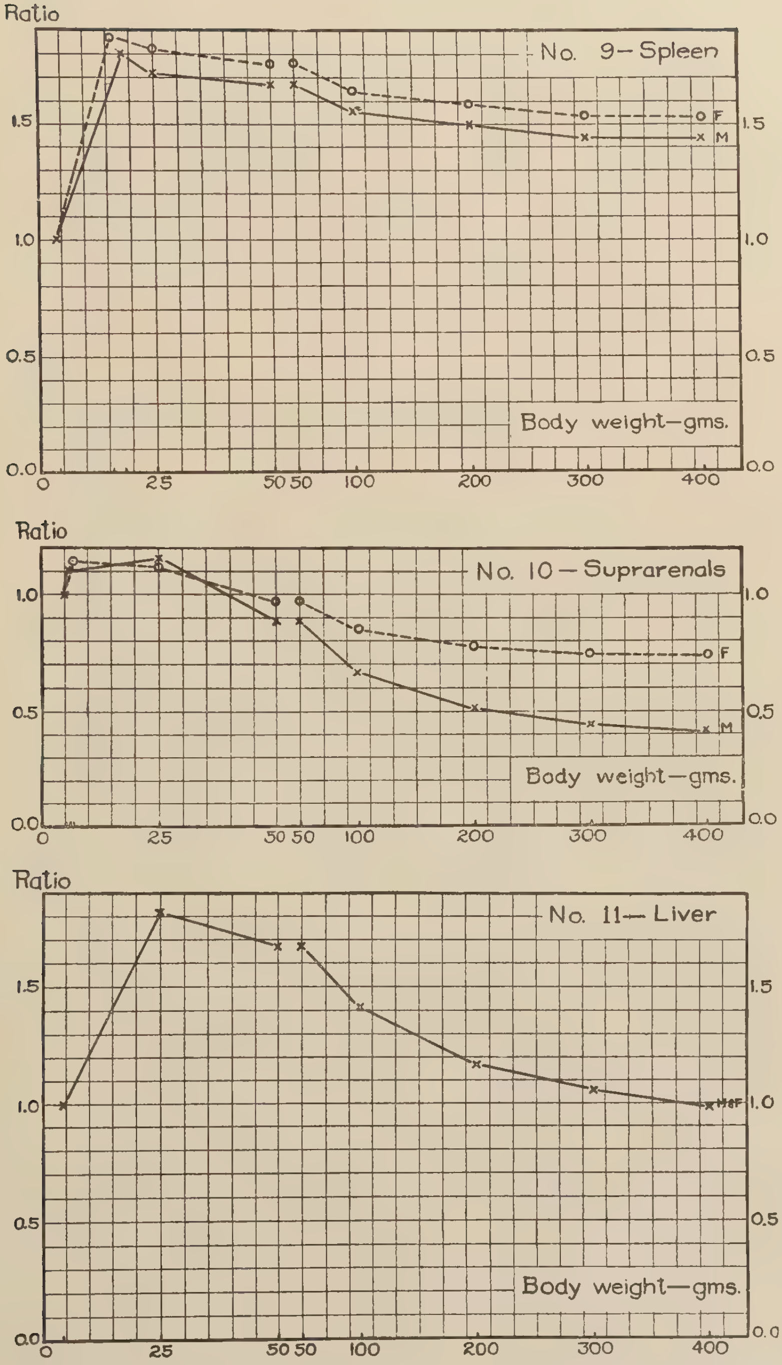


Chart 49—nos. 2–5. Showing the changes in the relative percentage weights of the lungs, hypophysis, thyroid and submaxillaries—based on the data in table 153. x————x, males; o----------o, females.



Charts 49—nos. 6–8. Showing the changes in the relative percentage weights of the kidneys, heart and pancreas—based on the data in table 156. x———x, males; o- - - - - -o, females.



Charts 49—nos. 9–11. Showing the changes in the relative percentage weights of the spleen, suprarenals and liver—based on the data in table 156. x————x, males; o---------o, females.

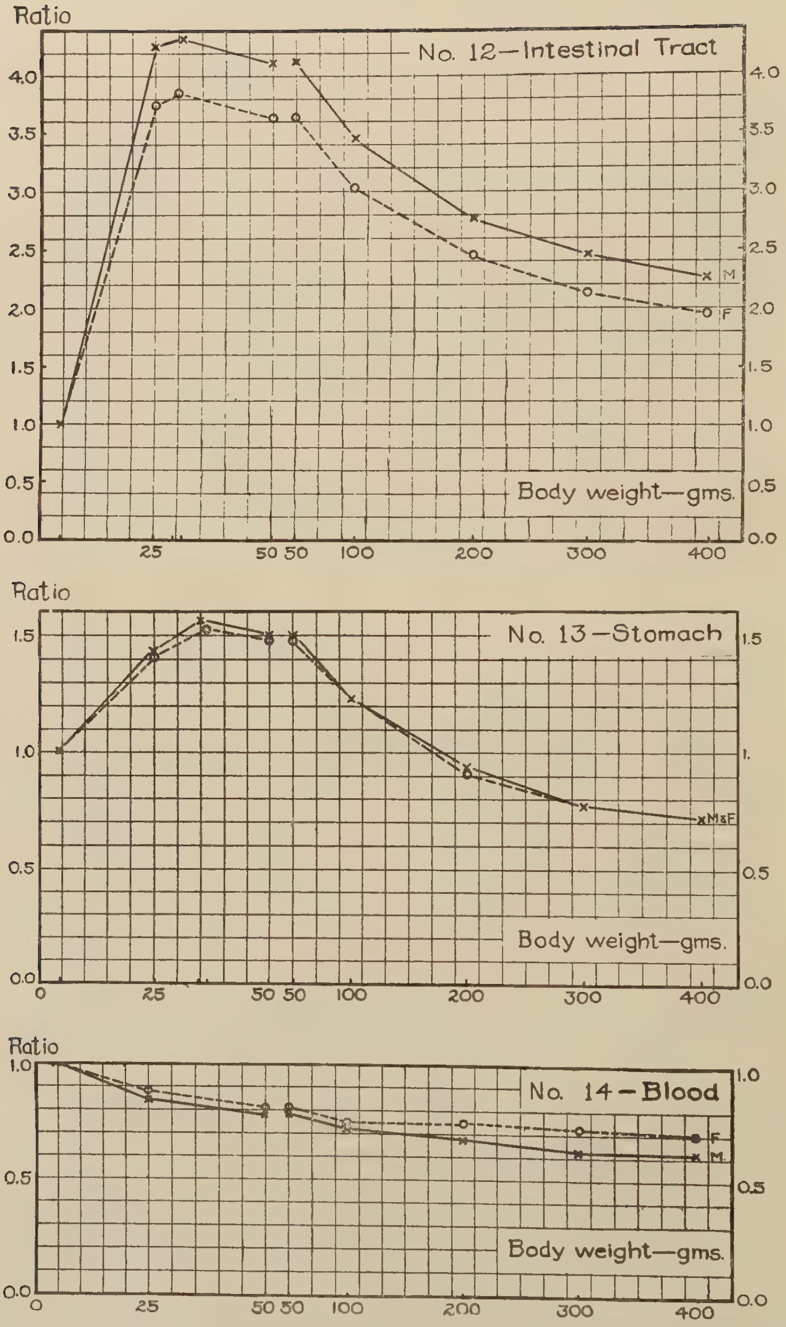


Chart 49—nos. 12–14. Showing the changes in the relative percentage weights of the intestinal tract, stomach and blood—based on the data in table 156. x———x, males; o-----------o, females.

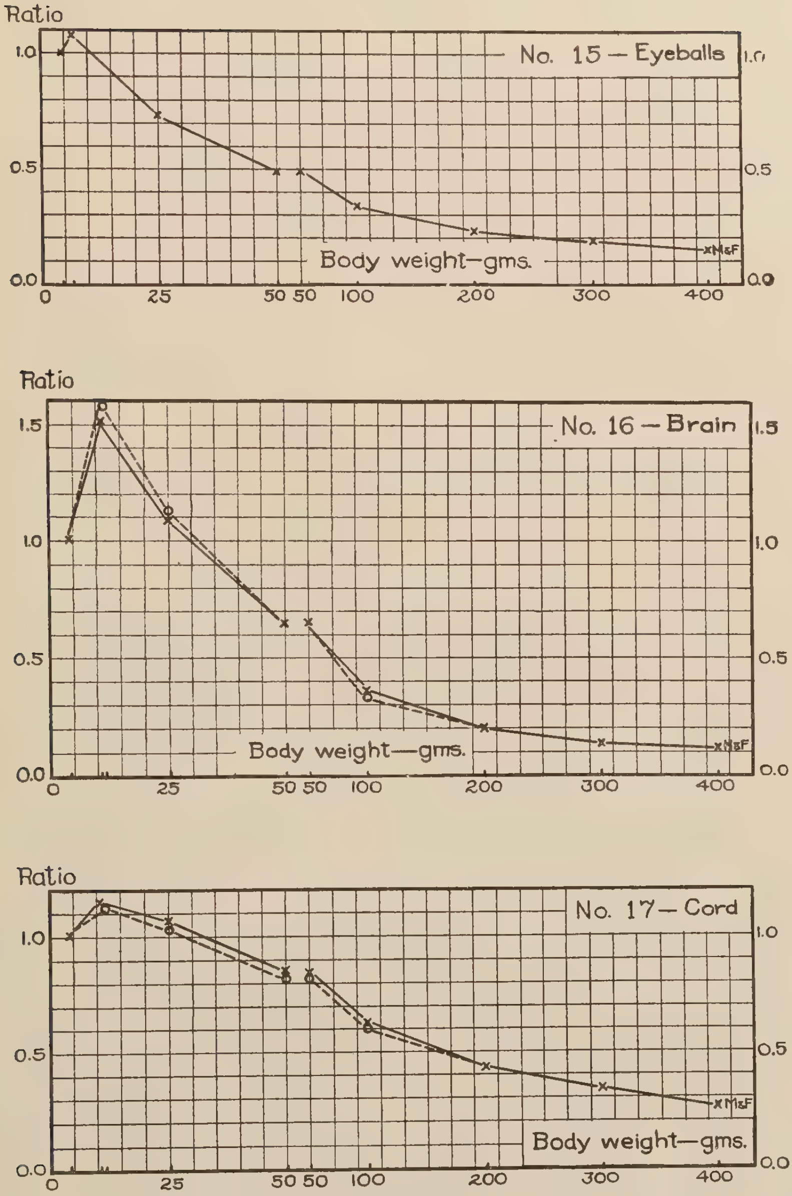


Chart 49—nos. 15–17. Showing the changes in the relative percentage weights of the eyeballs, brain, and spinal cord—based on the data in table 156. x————x, males; o----------o, females.

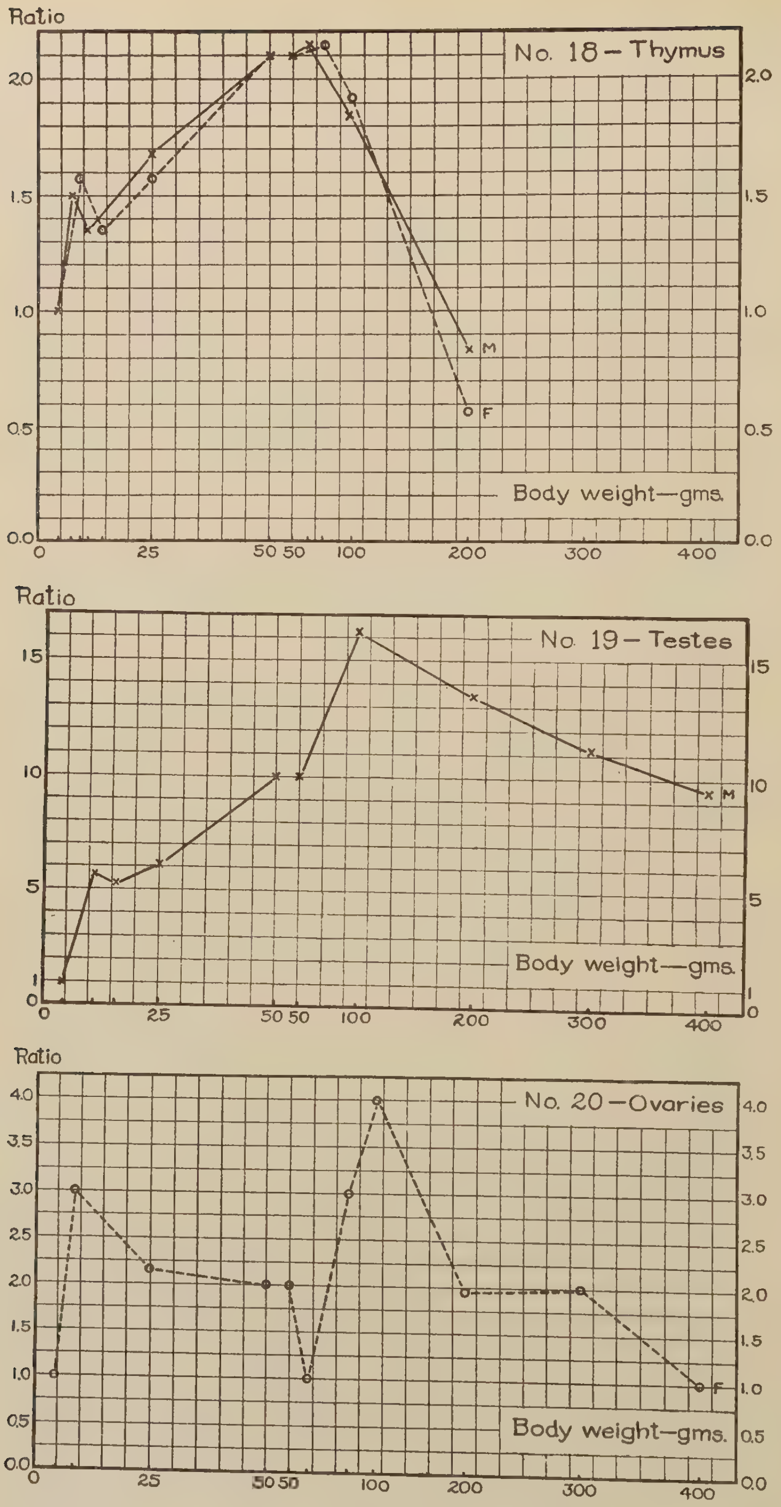


Chart 49—nos. 18–20. Showing the changes in the relative percentage weights of the thymus, testes and ovaries—based on the data in table 156. x————x, males; o----------o, females.

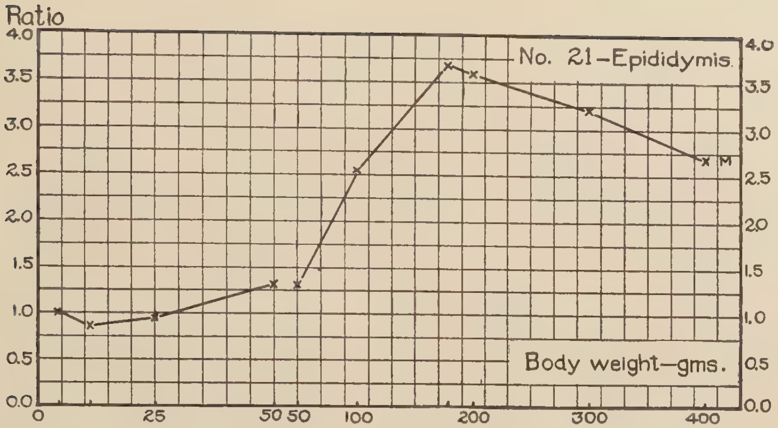


Chart 49—no. 21. Showing the changes in the relative percentage weights of the epididymides—based on the data in table 156. x————x, males; o----------o, females.

the organ into full function: that the relatively heavy viscera depend for their high weight mainly on the liver and intestines, and that the relative percentage weights of the blood and the endocrine glands are similar, suggesting that although the relative weight of the blood diminishes, its relations to the organs contributing to it are maintained. These changes in the organ composition of the rat require attention when interpreting its physiological responses.

11. *Values for other characters linked with age.* Table 157 contains the data for the "standard" body weight on age, for the weight of the brain and of the spinal cord and the percentages of water in them.

12. *Formulas.* Formulas have been devised mainly by Dr. Hatai for computing the length or weight of the body and of its several parts, systems or organs, also for expressing the values of other characters.

Three incidental formulas (1) (2) (3) have been given in the preceding pages.

Of the remaining formulas for the Albino—Group I—are given first, then those for the Norway—Group II. In Group I there are two divisions.

TABLE 157

*Giving the percentage of water in the brain and in the spinal cord for each sex, on age. See Chart 55*

| AGE IN DAYS | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord |
| B | 4.7 | 0.217 | 88.00 | 0.033 | 86.75 | 4.6 | 0.213 | 88.00 | 0.033 | 86.75 |
| 1 | 5.5 | 0.290 | 87.95 | 0.038 | 86.42 | 5.4 | 0.269 | 87.95 | 0.037 | 86.42 |
| 2 | 5.9 | 0.333 | 87.90 | 0.041 | 86.08 | 5.8 | 0.323 | 87.90 | 0.041 | 86.08 |
| 3 | 6.4 | 0.395 | 87.85 | 0.046 | 85.74 | 6.3 | 0.373 | 87.85 | 0.045 | 85.74 |
| 4 | 6.9 | 0.442 | 87.83 | 0.050 | 85.41 | 6.8 | 0.421 | 87.83 | 0.050 | 85.41 |
| 5 | 7.6 | 0.509 | 87.79 | 0.056 | 85.07 | 7.5 | 0.492 | 87.79 | 0.056 | 85.07 |
| 6 | 8.5 | 0.581 | 87.70 | 0.064 | 84.73 | 8.4 | 0.564 | 87.70 | 0.064 | 84.73 |
| 7 | 9.5 | 0.657 | 87.50 | 0.072 | 84.40 | 9.4 | 0.645 | 87.50 | 0.073 | 84.40 |
| 8 | 10.5 | 0.708 | 87.30 | 0.081 | 84.06 | 10.4 | 0.697 | 87.30 | 0.082 | 84.06 |
| 9 | 11.8 | 0.840 | 87.05 | 0.091 | 83.73 | 11.6 | 0.811 | 87.05 | 0.091 | 83.73 |
| 10 | 13.5 | 0.947 | 86.72 | 0.104 | 83.40 | 13.0 | 0.909 | 86.72 | 0.102 | 83.40 |
| 11 | 13.9 | 0.969 | 86.26 | 0.106 | 82.98 | 13.7 | 0.940 | 86.26 | 0.107 | 82.96 |
| 12 | 14.4 | 0.991 | 85.82 | 0.110 | 82.57 | 14.4 | 0.979 | 85.82 | 0.112 | 82.52 |
| 13 | 14.9 | 1.011 | 85.39 | 0.114 | 82.17 | 15.1 | 1.003 | 85.40 | 0.117 | 82.10 |
| 14 | 15.5 | 1.037 | 84.97 | 0.118 | 81.77 | 15.8 | 1.031 | 84.98 | 0.122 | 81.68 |
| 15 | 16.1 | 1.057 | 84.58 | 0.122 | 81.39 | 16.5 | 1.048 | 84.59 | 0.127 | 81.28 |
| 16 | 16.7 | 1.077 | 84.19 | 0.126 | 81.00 | 17.3 | 1.079 | 84.20 | 0.133 | 80.88 |
| 17 | 17.3 | 1.095 | 83.82 | 0.131 | 80.63 | 18.1 | 1.099 | 83.82 | 0.138 | 80.49 |
| 18 | 18.0 | 1.112 | 83.46 | 0.135 | 80.26 | 18.9 | 1.118 | 83.47 | 0.142 | 80.11 |
| 19 | 18.7 | 1.131 | 83.12 | 0.139 | 79.90 | 19.8 | 1.140 | 83.13 | 0.148 | 79.73 |
| 20 | 19.5 | 1.150 | 82.80 | 0.144 | 79.55 | 20.7 | 1.159 | 82.82 | 0.154 | 79.47 |
| 21 | 20.3 | 1.169 | 82.49 | 0.149 | 79.21 | 21.6 | 1.177 | 82.51 | 0.160 | 79.02 |
| 22 | 21.1 | 1.184 | 82.19 | 0.154 | 78.87 | 22.5 | 1.195 | 82.21 | 0.165 | 78.67 |
| 23 | 22.0 | 1.202 | 81.91 | 0.159 | 78.54 | 23.4 | 1.208 | 81.93 | 0.170 | 78.33 |
| 24 | 22.9 | 1.219 | 81.64 | 0.165 | 78.22 | 24.4 | 1.226 | 81.66 | 0.176 | 78.00 |
| 25 | 23.9 | 1.237 | 81.39 | 0.169 | 77.90 | 25.4 | 1.241 | 81.41 | 0.182 | 77.67 |
| 26 | 24.9 | 1.252 | 81.15 | 0.175 | 77.59 | 26.5 | 1.251 | 81.17 | 0.187 | 77.36 |
| 27 | 25.9 | 1.266 | 80.93 | 0.179 | 77.29 | 27.5 | 1.269 | 80.95 | 0.193 | 77.06 |
| 28 | 27.0 | 1.282 | 80.72 | 0.186 | 77.00 | 28.6 | 1.282 | 80.74 | 0.198 | 76.76 |
| 29 | 28.1 | 1.297 | 80.53 | 0.193 | 76.71 | 29.7 | 1.297 | 80.55 | 0.204 | 76.47 |
| 30 | 29.2 | 1.311 | 80.35 | 0.198 | 76.43 | 30.9 | 1.310 | 80.37 | 0.210 | 76.19 |
| 31 | 30.4 | 1.324 | 80.19 | 0.204 | 76.16 | 32.0 | 1.322 | 80.21 | 0.216 | 75.92 |
| 32 | 31.6 | 1.338 | 80.04 | 0.210 | 75.90 | 33.2 | 1.334 | 80.07 | 0.221 | 75.66 |
| 33 | 32.8 | 1.351 | 79.91 | 0.215 | 75.64 | 34.4 | 1.346 | 79.94 | 0.227 | 75.40 |
| 34 | 34.1 | 1.363 | 79.79 | 0.221 | 75.39 | 35.7 | 1.358 | 79.82 | 0.233 | 75.16 |
| 35 | 35.4 | 1.375 | 79.69 | 0.227 | 75.15 | 37.0 | 1.369 | 79.72 | 0.239 | 74.92 |
| 36 | 36.8 | 1.389 | 79.60 | 0.233 | 74.91 | 38.3 | 1.380 | 79.63 | 0.245 | 74.69 |

TABLE 157—Continued

| AGE IN DAYS | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord |
| 37 | 38.1 | 1.399 | 79.52 | 0.239 | 74.68 | 39.6 | 1.391 | 79.55 | 0.250 | 74.47 |
| 38 | 39.6 | 1.411 | 79.46 | 0.245 | 74.46 | 40.9 | 1.400 | 79.49 | 0.255 | 74.26 |
| 39 | 41.0 | 1.423 | 79.42 | 0.251 | 74.25 | 42.3 | 1.411 | 79.45 | 0.261 | 74.06 |
| 40 | 42.5 | 1.434 | 79.39 | 0.257 | 74.04 | 43.7 | 1.422 | 79.42 | 0.267 | 73.86 |
| 41 | 44.1 | 1.446 | 79.36 | 0.264 | 73.95 | 45.1 | 1.432 | 79.39 | 0.272 | 73.78 |
| 42 | 45.7 | 1.457 | 79.34 | 0.269 | 73.87 | 46.6 | 1.441 | 79.37 | 0.278 | 73.72 |
| 43 | 47.3 | 1.468 | 79.32 | 0.276 | 73.74 | 48.1 | 1.451 | 79.35 | 0.284 | 73.60 |
| 44 | 48.9 | 1.478 | 79.30 | 0.281 | 73.62 | 49.6 | 1.460 | 79.33 | 0.289 | 73.50 |
| 45 | 50.6 | 1.488 | 79.28 | 0.288 | 73.50 | 51.1 | 1.468 | 79.31 | 0.294 | 73.39 |
| 46 | 52.3 | 1.498 | 79.26 | 0.293 | 73.39 | 52.7 | 1.478 | 79.29 | 0.300 | 73.30 |
| 47 | 54.1 | 1.507 | 79.24 | 0.299 | 73.28 | 54.3 | 1.487 | 79.27 | 0.306 | 73.21 |
| 48 | 55.9 | 1.518 | 79.22 | 0.305 | 73.17 | 55.9 | 1.495 | 79.25 | 0.311 | 73.12 |
| 49 | 57.7 | 1.527 | 79.21 | 0.311 | 73.07 | 57.5 | 1.503 | 79.24 | 0.316 | 72.05 |
| 50 | 59.6 | 1.537 | 79.19 | 0.317 | 72.97 | 59.2 | 1.512 | 79.23 | 0.322 | 72.97 |
| 51 | 61.5 | 1.546 | 79.17 | 0.323 | 72.88 | 60.9 | 1.520 | 79.21 | 0.327 | 72.88 |
| 52 | 63.4 | 1.555 | 79.15 | 0.329 | 72.79 | 62.6 | 1.528 | 79.19 | 0.332 | 72.79 |
| 53 | 65.4 | 1.563 | 79.14 | 0.334 | 72.69 | 64.3 | 1.535 | 79.18 | 0.338 | 72.69 |
| 54 | 67.4 | 1.572 | 79.12 | 0.340 | 72.60 | 66.1 | 1.543 | 79.16 | 0.343 | 72.60 |
| 55 | 69.5 | 1.581 | 79.10 | 0.346 | 72.51 | 67.9 | 1.551 | 79.14 | 0.348 | 72.51 |
| 56 | 71.6 | 1.589 | 79.08 | 0.352 | 72.43 | 69.7 | 1.558 | 79.12 | 0.353 | 72.43 |
| 57 | 73.7 | 1.597 | 79.07 | 0.358 | 72.35 | 71.6 | 1.565 | 79.11 | 0.359 | 72.35 |
| 58 | 75.9 | 1.606 | 79.05 | 0.363 | 72.27 | 73.4 | 1.573 | 79.09 | 0.364 | 72.27 |
| 59 | 78.1 | 1.614 | 79.04 | 0.369 | 72.19 | 75.3 | 1.580 | 79.08 | 0.370 | 72.19 |
| 60 | 80.3 | 1.622 | 79.02 | 0.375 | 72.11 | 77.3 | 1.587 | 79.06 | 0.375 | 72.11 |
| 61 | 82.5 | 1.629 | 79.00 | 0.380 | 72.04 | 79.2 | 1.594 | 79.04 | 0.380 | 72.04 |
| 62 | 84.9 | 1.637 | 78.99 | 0.386 | 71.97 | 81.2 | 1.601 | 79.02 | 0.385 | 71.97 |
| 63 | 87.2 | 1.644 | 78.97 | 0.391 | 71.91 | 83.2 | 1.607 | 79.01 | 0.389 | 71.91 |
| 64 | 89.6 | 1.652 | 78.96 | 0.397 | 71.84 | 85.2 | 1.614 | 78.99 | 0.394 | 71.84 |
| 65 | 92.0 | 1.659 | 78.94 | 0.402 | 71.77 | 87.3 | 1.621 | 78.98 | 0.399 | 71.77 |
| 66 | 94.5 | 1.666 | 78.93 | 0.407 | 71.71 | 89.4 | 1.627 | 78.97 | 0.404 | 71.72 |
| 67 | 97.0 | 1.673 | 78.92 | 0.413 | 71.65 | 91.5 | 1.633 | 78.96 | 0.409 | 71.66 |
| 68 | 99.5 | 1.681 | 78.90 | 0.418 | 71.60 | 93.6 | 1.639 | 78.94 | 0.414 | 71.61 |
| 69 | 102.1 | 1.688 | 78.89 | 0.424 | 71.54 | 95.8 | 1.645 | 78.93 | 0.419 | 71.54 |
| 70 | 104.7 | 1.695 | 78.88 | 0.429 | 71.48 | 98.0 | 1.651 | 78.92 | 0.424 | 71.50 |
| 71 | 107.3 | 1.702 | 78.87 | 0.434 | 71.43 | 100.2 | 1.657 | 78.91 | 0.429 | 71.45 |
| 72 | 110.0 | 1.709 | 78.85 | 0.439 | 71.38 | 102.4 | 1.663 | 78.89 | 0.433 | 71.41 |
| 73 | 112.7 | 1.715 | 78.84 | 0.445 | 71.32 | 104.7 | 1.669 | 78.88 | 0.438 | 71.36 |
| 74 | 115.5 | 1.722 | 78.82 | 0.450 | 71.27 | 107.0 | 1.675 | 78.86 | 0.442 | 71.32 |

TABLE 157—Continued

| AGE IN DAYS | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord |
| 75 | 118.3 | 1.729 | 78.81 | 0.455 | 71.22 | 109.3 | 1.681 | 78.85 | 0.447 | 71.27 |
| 76 | 121.1 | 1.735 | 78.80 | 0.460 | 71.18 | 111.6 | 1.687 | 78.84 | 0.451 | 71.23 |
| 77 | 124.0 | 1.741 | 78.79 | 0.465 | 71.13 | 114.0 | 1.692 | 78.83 | 0.456 | 71.19 |
| 78 | 126.8 | 1.746 | 78.77 | 0.470 | 71.09 | 116.4 | 1.698 | 78.82 | 0.460 | 71.15 |
| 79 | 129.8 | 1.752 | 78.76 | 0.475 | 71.04 | 118.8 | 1.703 | 78.81 | 0.465 | 71.11 |
| 80 | 132.8 | 1.758 | 78.75 | 0.480 | 71.00 | 121.3 | 1.709 | 78.80 | 0.469 | 71.07 |
| 81 | 134.7 | 1.762 | 78.74 | 0.483 | 70.96 | 122.6 | 1.712 | 78.79 | 0.471 | 71.03 |
| 82 | 136.5 | 1.765 | 78.73 | 0.486 | 70.92 | 124.0 | 1.715 | 78.78 | 0.474 | 71.00 |
| 83 | 138.4 | 1.769 | 78.72 | 0.488 | 70.89 | 125.4 | 1.717 | 78.77 | 0.476 | 70.96 |
| 84 | 140.2 | 1.772 | 78.71 | 0.491 | 70.85 | 126.8 | 1.720 | 78.76 | 0.479 | 70.93 |
| 85 | 142.0 | 1.776 | 78.70 | 0.494 | 70.81 | 128.1 | 1.723 | 78.75 | 0.481 | 70.89 |
| 86 | 143.7 | 1.779 | 78.69 | 0.497 | 70.78 | 129.5 | 1.726 | 78.74 | 0.483 | 70.86 |
| 87 | 145.5 | 1.782 | 78.68 | 0.499 | 70.74 | 130.8 | 1.728 | 78.73 | 0.485 | 70.83 |
| 88 | 147.2 | 1.785 | 78.67 | 0.502 | 70.71 | 132.1 | 1.731 | 78.72 | 0.488 | 70.80 |
| 89 | 148.9 | 1.788 | 78.66 | 0.504 | 70.67 | 133.4 | 1.733 | 78.71 | 0.490 | 70.77 |
| 90 | 150.5 | 1.791 | 78.65 | 0.507 | 70.64 | 134.6 | 1.736 | 78.70 | 0.492 | 70.74 |
| 91 | 152.1 | 1.794 | 78.64 | 0.509 | 70.61 | 135.8 | 1.738 | 78.69 | 0.494 | 70.72 |
| 92 | 153.7 | 1.797 | 78.63 | 0.511 | 70.58 | 137.1 | 1.740 | 78.68 | 0.496 | 70.69 |
| 93 | 155.3 | 1.799 | 78.62 | 0.514 | 70.56 | 138.3 | 1.743 | 78.67 | 0.497 | 70.67 |
| 94 | 156.9 | 1.802 | 78.61 | 0.516 | 70.53 | 139.4 | 1.745 | 78.66 | 0.499 | 70.64 |
| 95 | 158.4 | 1.805 | 78.60 | 0.518 | 70.50 | 140.6 | 1.747 | 78.65 | 0.501 | 70.62 |
| 96 | 160.0 | 1.807 | 78.59 | 0.520 | 70.48 | 141.8 | 1.749 | 78.64 | 0.503 | 70.60 |
| 97 | 161.4 | 1.810 | 78.58 | 0.522 | 70.45 | 142.9 | 1.751 | 78.63 | 0.505 | 70.58 |
| 98 | 162.9 | 1.812 | 78.57 | 0.525 | 70.43 | 144.0 | 1.752 | 78.62 | 0.506 | 70.55 |
| 99 | 164.3 | 1.815 | 78.56 | 0.527 | 70.40 | 145.1 | 1.754 | 78.61 | 0.508 | 70.53 |
| 100 | 165.8 | 1.817 | 78.55 | 0.529 | 70.38 | 146.2 | 1.756 | 78.60 | 0.510 | 70.51 |
| 101 | 167.2 | 1.819 | 78.54 | 0.531 | 70.36 | 147.3 | 1.758 | 78.59 | 0.512 | 70.49 |
| 102 | 168.6 | 1.821 | 78.53 | 0.533 | 70.34 | 148.3 | 1.760 | 78.58 | 0.514 | 70.47 |
| 103 | 170.0 | 1.824 | 78.53 | 0.534 | 70.32 | 149.4 | 1.762 | 78.58 | 0.515 | 70.46 |
| 104 | 171.3 | 1.826 | 78.52 | 0.536 | 70.30 | 150.4 | 1.764 | 78.57 | 0.517 | 70.44 |
| 105 | 172.7 | 1.828 | 78.51 | 0.538 | 70.28 | 151.4 | 1.766 | 78.56 | 0.519 | 70.42 |
| 106 | 174.0 | 1.830 | 78.50 | 0.540 | 70.26 | 152.4 | 1.768 | 78.55 | 0.520 | 60.41 |
| 107 | 175.3 | 1.832 | 78.49 | 0.541 | 70.25 | 153.4 | 1.770 | 78.54 | 0.522 | 70.40 |
| 108 | 176.6 | 1.833 | 78.48 | 0.543 | 70.23 | 154.4 | 1.772 | 78.53 | 0.523 | 70.38 |
| 109 | 177.9 | 1.835 | 78.47 | 0.544 | 70.22 | 155.3 | 1.774 | 78.52 | 0.525 | 70.37 |
| 110 | 179.1 | 1.837 | 78.46 | 0.546 | 70.20 | 156.3 | 1.775 | 78.51 | 0.526 | 70.36 |
| 111 | 180.4 | 1.839 | 78.45 | 0.547 | 70.19 | 157.2 | 1.776 | 78.50 | 0.527 | 70.35 |
| 112 | 181.6 | 1.841 | 78.44 | 0.549 | 70.17 | 158.2 | 1.778 | 78.49 | 0.528 | 70.34 |

TABLE 157—Continued

| AGE IN DAYS | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord |
| 113 | 182.8 | 1.842 | 78.44 | 0.550 | 70.15 | 159.1 | 1.779 | 78.49 | 0.530 | 70.32 |
| 114 | 184.0 | 1.844 | 78.43 | 0.552 | 70.14 | 160.0 | 1.781 | 78.48 | 0.531 | 70.31 |
| 115 | 185.2 | 1.846 | 78.42 | 0.553 | 70.13 | 160.9 | 1.782 | 78.47 | 0.532 | 70.30 |
| 116 | 186.4 | 1.848 | 78.41 | 0.555 | 70.12 | 161.8 | 1.783 | 78.46 | 0.533 | 70.29 |
| 117 | 187.5 | 1.849 | 78.40 | 0.556 | 70.11 | 162.6 | 1.785 | 78.46 | 0.535 | 70.28 |
| 118 | 188.7 | 1.851 | 78.40 | 0.558 | 70.09 | 163.5 | 1.786 | 78.45 | 0.536 | 70.27 |
| 119 | 189.7 | 1.852 | 78.39 | 0.559 | 70.08 | 164.3 | 1.788 | 78.45 | 0.538 | 70.26 |
| 120 | 190.9 | 1.854 | 78.38 | 0.561 | 70.07 | 165.2 | 1.789 | 78.44 | 0.539 | 70.25 |
| 121 | 192.0 | 1.855 | 78.37 | 0.562 | 70.06 | 166.0 | 1.790 | 78.43 | 0.540 | 70.25 |
| 122 | 193.1 | 1.857 | 78.37 | 0.563 | 70.06 | 166.8 | 1.791 | 78.43 | 0.541 | 70.24 |
| 123 | 194.1 | 1.858 | 78.36 | 0.564 | 70.05 | 167.6 | 1.793 | 78.42 | 0.542 | 70.24 |
| 124 | 195.2 | 1.860 | 78.36 | 0.565 | 70.05 | 168.4 | 1.794 | 78.42 | 0.543 | 70.23 |
| 125 | 196.2 | 1.861 | 78.35 | 0.566 | 70.04 | 169.2 | 1.795 | 78.41 | 0.544 | 70.23 |
| 126 | 197.3 | 1.862 | 78.34 | 0.567 | 70.03 | 170.0 | 1.796 | 78.40 | 0.545 | 70.23 |
| 127 | 198.3 | 1.863 | 78.33 | 0.569 | 70.03 | 170.7 | 1.798 | 78.39 | 0.546 | 70.23 |
| 128 | 199.3 | 1.865 | 78.33 | 0.570 | 70.02 | 171.5 | 1.799 | 78.39 | 0.546 | 70.22 |
| 129 | 200.3 | 1.866 | 78.32 | 0.572 | 70.02 | 172.3 | 1.801 | 78.38 | 0.547 | 70.22 |
| 130 | 201.2 | 1.867 | 78.31 | 0.573 | 70.01 | 173.0 | 1.802 | 78.37 | 0.548 | 70.22 |
| 131 | 202.2 | 1.868 | 78.30 | 0.574 | 70.01 | 173.7 | 1.803 | 78.36 | 0.549 | 70.22 |
| 132 | 203.2 | 1.870 | 78.30 | 0.575 | 70.01 | 174.5 | 1.804 | 78.36 | 0.550 | 70.22 |
| 133 | 204.1 | 1.871 | 78.29 | 0.576 | 70.00 | 175.2 | 1.804 | 78.35 | 0.551 | 70.22 |
| 134 | 205.1 | 1.873 | 78.29 | 0.577 | 70.00 | 175.9 | 1.805 | 78.35 | 0.552 | 70.22 |
| 135 | 206.0 | 1.874 | 78.28 | 0.578 | 70.00 | 176.6 | 1.806 | 78.34 | 0.553 | 70.22 |
| 136 | 206.9 | 1.875 | 78.27 | 0.579 | 70.00 | 177.3 | 1.807 | 78.33 | 0.554 | 70.22 |
| 137 | 207.8 | 1.876 | 78.26 | 0.580 | 70.00 | 178.0 | 1.808 | 78.32 | 0.555 | 70.22 |
| 138 | 208.7 | 1.877 | 78.26 | 0.580 | 70.00 | 178.6 | 1.809 | 78.32 | 0.555 | 70.22 |
| 139 | 209.6 | 1.878 | 78.25 | 0.581 | 70.00 | 179.2 | 1.810 | 78.31 | 0.556 | 70.22 |
| 140 | 210.5 | 1.879 | 78.24 | 0.582 | 70.00 | 179.9 | 1.811 | 78.30 | 0.557 | 70.22 |
| 141 | 211.3 | 1.880 | 78.24 | 0.583 | 70.00 | 180.6 | 1.812 | 78.30 | 0.558 | 70.22 |
| 142 | 212.2 | 1.881 | 78.23 | 0.584 | 70.00 | 181.2 | 1.813 | 78.29 | 0.559 | 70.22 |
| 143 | 213.0 | 1.882 | 78.23 | 0.584 | 70.00 | 181.8 | 1.813 | 78.29 | 0.559 | 70.22 |
| 144 | 213.9 | 1.883 | 78.22 | 0.585 | 70.00 | 182.5 | 1.814 | 78.28 | 0.560 | 70.22 |
| 145 | 214.7 | 1.884 | 78.22 | 0.586 | 70.00 | 183.1 | 1.815 | 78.28 | 0.561 | 70.22 |
| 146 | 215.5 | 1.885 | 78.21 | 0.587 | 70.00 | 183.7 | 1.816 | 78.27 | 0.562 | 70.22 |
| 147 | 216.3 | 1.886 | 78.21 | 0.588 | 70.00 | 184.3 | 1.817 | 78.27 | 0.562 | 70.22 |
| 148 | 217.1 | 1.887 | 78.20 | 0.588 | 70.00 | 184.9 | 1.817 | 78.26 | 0.563 | 70.22 |
| 149 | 217.9 | 1.887 | 78.20 | 0.589 | 70.00 | 185.5 | 1.818 | 78.26 | 0.564 | 70.22 |
| 150 | 218.7 | 1.888 | 78.19 | 0.590 | 70.00 | 186.1 | 1.819 | 78.25 | 0.565 | 70.22 |

TABLE 157—Concluded

| AGE IN DAYS | MALES | | | | | FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord | Body weight *gms.* | Brain weight *gms.* | Per cent of water brain | Cord weight *gms.* | Per cent of water cord |
| 160 | 226.0 | 1.898 | 78.14 | 0.598 | 70.00 | 191.6 | 1.827 | 78.20 | 0.572 | 70.22 |
| 170 | 232.6 | 1.905 | 78.12 | 0.605 | 70.00 | 196.5 | 1.834 | 78.18 | 0.578 | 70.22 |
| 180 | 238.6 | 1.911 | 78.11 | 0.610 | 69.99 | 201.0 | 1.839 | 78.17 | 0.583 | 70.22 |
| 190 | 243.9 | 1.917 | 78.11 | 0.616 | 69.99 | 204.9 | 1.845 | 78.17 | 0.588 | 70.22 |
| 200 | 248.6 | 1.922 | 78.10 | 0.620 | 69.97 | 208.4 | 1.849 | 78.17 | 0.592 | 70.20 |
| 210 | 252.9 | 1.927 | 78.09 | 0.624 | 69.94 | 211.6 | 1.853 | 78.16 | 0.595 | 70.19 |
| 220 | 256.8 | 1.931 | 78.08 | 0.628 | 69.91 | 214.4 | 1.857 | 78.15 | 0.598 | 70.16 |
| 230 | 260.2 | 1.934 | 78.06 | 0.631 | 69.88 | 217.0 | 1.860 | 78.13 | 0.601 | 70.13 |
| 240 | 263.3 | 1.937 | 78.04 | 0.634 | 69.84 | 219.2 | 1.863 | 78.11 | 0.603 | 70.10 |
| 250 | 266.1 | 1.940 | 78.01 | 0.636 | 69.79 | 221.2 | 1.865 | 78.08 | 0.605 | 70.05 |
| 260 | 268.5 | 1.943 | 77.98 | 0.639 | 69.74 | 223.0 | 1.866 | 78.05 | 0.607 | 70.00 |
| 270 | 270.7 | 1.945 | 77.95 | 0.641 | 69.70 | 224.5 | 1.868 | 78.02 | 0.609 | 69.96 |
| 280 | 272.5 | 1.946 | 77.92 | 0.642 | 69.65 | 225.8 | 1.869 | 77.99 | 0.610 | 69.91 |
| 290 | 274.2 | 1.948 | 77.88 | 0.643 | 69.60 | 226.9 | 1.870 | 77.96 | 0.611 | 69.87 |
| 300 | 275.5 | 1.949 | 77.84 | 0.644 | 69.54 | 227.9 | 1.871 | 77.92 | 0.612 | 69.82 |
| 310 | 276.7 | 1.950 | 77.80 | 0.645 | 69.48 | 228.7 | 1.872 | 77.88 | 0.613 | 69.77 |
| 320 | 277.7 | 1.950 | 77.75 | 0.646 | 69.42 | 229.3 | 1.872 | 77.83 | 0.613 | 69.71 |
| 330 | 278.5 | 1.951 | 77.70 | 0.647 | 69.36 | 229.8 | 1.873 | 77.78 | 0.614 | 69.66 |
| 340 | 279.1 | 1.952 | 77.65 | 0.648 | 69.30 | 230.1 | 1.874 | 77.73 | 0.615 | 69.60 |
| 350 | 279.6 | 1.953 | 77.59 | 0.648 | 69.23 | 230.3 | 1.874 | 77.67 | 0.615 | 69.54 |
| 360 | 279.8 | 1.954 | 77.53 | 0.649 | 69.16 | 230.4 | 1.875 | 77.61 | 0.616 | 69.47 |
| 365 | 279.9 | 1.954 | 77.50 | 0.649 | 69.13 | 230.4 | 1.875 | 77.58 | 0.616 | 69.44 |

The first division comprises the formula based on size (body length and body weight). The second division comprises the formulas based on age. These formulas have been kept simple in order to facilitate their use. This condition has made it sometimes necessary to have different formulas for the different parts of the same series of data, but this was deemed more desirable than a reduction in the number of the formulas at the price of greater complexity.

After the formula there follows in parenthesis the number by which it is designated in the text, and every formula, whether it be general or subsidiary, is thus numbered, each subsidiary formula carrying the number of the general formula to which it is related, followed by a distinguishing letter. A catalog of the formulas, given in detail later, is here presented.

TABLE 157A

*Body weight on age. Data used for graph by Greenman and Duhring ('23). These rats had been given exercise and were specially well cared for and fed*

| MALES | | | FEMALES | |
|---|---|---|---|---|
| Age | Number of rats | Body weight | Number of rats | Body weight |
| *days* | | *grams* | | *grams* |
| Birth | 129 | 5.39 | 140 | 5.12 |
| 1 | 118 | 5.96 | 136 | 5.55 |
| 2 | 120 | 6.42 | 139 | 6.30 |
| 3 | 125 | 7.24 | 155 | 7.00 |
| 4 | 130 | 8.33 | 137 | 8.06 |
| 5 | 134 | 9.47 | 137 | 8.92 |
| 6 | 134 | 10.67 | 152 | 10.21 |
| 7 | 115 | 11.90 | 125 | 11.37 |
| 8 | 126 | 13.61 | 138 | 12.95 |
| 9 | 122 | 14.65 | 140 | 14.31 |
| 10 | 137 | 15.47 | 157 | 14.90 |
| 11 | 131 | 16.97 | 134 | 16.58 |
| 12 | 127 | 18.13 | 133 | 17.01 |
| 13 | 126 | 18.80 | 139 | 18.02 |
| 14 | 116 | 20.44 | 126 | 19.15 |
| 15 | 111 | 21.64 | 124 | 20.09 |
| 22 | 51 | 26.43 | 69 | 26.38 |
| 25 | 56 | 32.98 | 56 | 32.25 |
| 30 | 45 | 41.83 | 54 | 39.22 |
| 37 | 35 | 54.50 | 39 | 50.44 |
| 52 | 32 | 80.85 | 37 | 73.63 |
| 67 | 30 | 112.04 | 33 | 102.23 |
| 82 | 25 | 145.73 | 31 | 137.05 |
| 97 | 22 | 169.02 | 29 | 157.85 |
| 120 | 52 | 240.40 | 69 | 179.58 |
| 150 | 68 | 263.92 | 80 | 191.72 |
| 182 | 108 | 289.61 | 115 | 198.67 |
| 212 | 107 | 303.32 | 109 | 209.36 |
| 242 | 106 | 318.88 | 106 | 220.51 |
| 272 | 104 | 328.70 | 108 | 224.61 |
| 295 | 100 | 337.05 | 104 | 235.65 |
| 325 | 95 | 338.46 | 104 | 238.82 |
| 356 | 95 | 341.46 | 94 | 246.14 |
| 384 | 83 | 349.06 | 85 | 254.25 |
| 415 | 79 | 353.86 | 84 | 256.62 |
| 450 | 70 | 369.32 | 87 | 263.84 |

## CATALOG OF FORMULAS

### GROUP I. ALBINOS

*First division: Formulas based on size*

Body length on body weight (4).
Body weight on body length (5), (5 a), (5 b).
Body weight on brain weight (6).
Tail length on body length (7), (8).
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Area of callosum on body weight (11).
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Diameters of ganglion cell and nucleus (14), (14 a).
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Weight of pancreas on body weight (25), (25 a).
Weight of submaxillaries on body weight (26).
Weight of both testes on body weight (27), (28), (29).
Weight of epididymides on body weight (30), (31).
Weight of both ovaries on body weight (32), (33), (34).
Weight of hypophysis on body weight (35), (36).
Weight of both suprarenals on body weight (37), (38).
Weight of thyroid on body weight (39).
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*Second division: Formulas based on age in days*

Body weight on age (41), (42), (43), (44).
Weight of thymus on age (45), (46).
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### GROUP II. NORWAYS

*First division: Formulas based on size*

Body length on body weight (53).
Body weight on body length (54), (55).
Tail length on body length (56), (57).
Brain weight on body weight (58).
Cranial capacity on body weight (59).
Spinal cord weight on body weight (60).
Spinal cord weight on brain weight (61).

## GROUP I. ALBINOS

### FIRST DIVISION: FORMULAS BASED ON SIZE

### Body Length on Body Weight, (Donaldson, '09)

*Body length (sexes combined)* $= 143\,\mathit{log}\,(\mathit{Bd.\,wt.} + 15) - 134$ (4).

A study of tables 1 and 2 in the investigations by Donaldson ('09) shows that for a given body weight the body length of the male is about 2.2 per cent greater than that of the female. If then the value found by this formula for any body weight is increased by 1.1 per cent of itself the sum obtained represents the body length for the male. If on the contrary, the value found is decreased by 1.1 per cent of itself, the difference obtained represents the body length for the corresponding female.

### Body Weight on Body Length (Donaldson, '09)

By transposing formula (4) we obtain

$$\mathit{Body\ weight\ (sexes\ combined)} = 10^{\frac{Bd.l.+134}{143}} - 15 \qquad (5)$$

As the body length for a given body weight is for the male 1.1 per cent above the value in (5) and for the female 1.1 per cent below the value in (5) two new formulas have been made for the male and female respectively—thus

$$\mathit{Body\ weight{:}\!\!-\!\!male} = 10^{\frac{(100\,Bd.\,l.-1\ 1\,Bd.\,l)+13400}{14300}} - 15 \qquad (5a)$$

$$\mathit{Body\ weight{:}\!\!-\!\!female} = 10^{\frac{(100\,Bd.\,l.+1.1\,Bd.\,l.)+13400}{14300}} - 15 \qquad (5b)$$

By use of formulas (5 a) and (5 b) the body weights corresponding to body lengths from 70–250 mm. have been computed for each sex and the values obtained are those entered in the accompanying tables.

To illustrate the procedure with a formula of this sort the following example is given.

To compute the body weight for a body length of 150 mm. (male) by the following formula (5 a).

$$\mathit{Body\ weight\ (male)} = 10^{\frac{(100\,Bd.\,l.-1.1\,Bd.\,l.+13400)}{14300}} - 15$$

Transpose 15 from right hand side to the left and take the logarithm of both sides. We have

$$log\ (Bd.wt. + 15) = log\ 10 \times \frac{(100 \times 150 - 1.1 \times 150) + 13400}{14300}$$

$$1 \times \frac{15000 - 165 + 13400}{14300} = 1.9745$$

Thus 1.9745 is equivalent to the logarithm of body weight plus 15. Therefore body weight + 15 = 94.3 (anti-logarithm of 1.9745). Finally, body weight = 94.3 − 15 = 79.3 grams.

The above procedure is that to be followed with other formulas of the same type.

### Body Weight on Brain Weight (Donaldson, '08)

$$\textit{Body weight (sexes combined)} = 8.7 + 10^{\frac{Br.\ wt. - 0.554}{0.569}} \qquad (6)$$

### Tail Length on Body Length (Hatai, ms '14)

$$\textit{Tail length: male} = 0.852\ Bd.\ l. + 38.8\ (log\ Bd.\ l.) - 90.5 \qquad (7)$$

$$\textit{Tail length:—female} = 0.874\ Bd.\ l. + 43.2\ (log\ Bd.\ l) - 98.1 \qquad (8)$$

Formulas (7) and (8) were used for table 144.

### Brain Weight on Body Weight (Hatai, '09 a, p. 172)

For the brain weight of sexes combined, the following formulas have been obtained:—

$$\textit{Brain weight (sexes combined)} = 1.56\ log\ (Bd.\ wt.) - 0.87 \qquad (9)$$

$$[5 < Bd.\ wt. < 10\ gms.]$$

$$\textit{Brain weight (sexes combined)} =$$

$$0.569\ log\ (Bd.\ wt. - 8.7) + 0.554 \qquad (10)$$

$$Bd.\ wt. > 10\ gms.]$$

For a given body weight the average brain weight in the male was found to be 1.5 per cent more than in the female, hence the determinations of brain weight on body weight by formulas (9) and (10) give final values which must be increased by 0.75 per cent to represent the male brain and decreased by 0.75 per cent to represent the female brain weight. By using this procedure the data on brain weight given in table 144 were obtained.

### AREA OF CALLOSUM (SUITSU, '20)

The theoretical curve, about which the observations cluster, is represented by the continuous line in chart 8 and was computed by means of the formula:

$$y = 0.184 + 0.0003\,x + 2.08 \log x \qquad (11)$$

in which $y$ is the area of the callosum in the sagittal section, in millimeters, and $x$ the weight of the body, in grams. This formula is based on the general formula $y = a + bx + c \log x$, already published by Hatai ('11).

### CRANIAL CAPACITY (DONALDSON, '12)

For the cranial capacity expressed in cc. the formula for sexes combined is

$$\textit{Cranial capacity in cc.} =$$

$$1.02 \log \textit{Bd. wt.} - 0.00027\,\textit{Bd. wt.} - 0.596 \qquad (12)$$

$$[80 < \textit{Bd. wt.} < 300]$$

### SPINAL CORD WEIGHT ON BODY WEIGHT (DONALDSON, '09)

$$\textit{Spinal cord wt. (sexes combined)} =$$

$$0.585 \log (\textit{Bd. wt.} + 21) - 0.795 \qquad (13)$$

In the female the spinal cord is about 2 per cent heavier than in the male, therefore when using formula (13) the values obtained require to be increased by 1 per cent to represent the weight of the spinal cord in the female and to be diminished by

1 per cent to represent its weight in the male. By using this procedure, the data on the weights of the spinal cord in table 144 have been obtained.

### DIAMETER OF SECOND CERVICAL SPINAL GANGLION CELL NUCLEUS ON DIAMETER OF CELL BODY (HATAI, '07 b)

Correlation between diameter of cell body and diameter of nucleus in $\mu$ – in spinal ganglion cells of second cervical nerve.

*Diameter of nucleus in* $\mu$ =

$$12.2939 \left\{ 1.0252 + 0.3564 \left( \frac{x}{l} \right) - 0.0758 \left( \frac{x}{l} \right)^2 \right\} \quad (14)$$

where x is the diameter of the cell in $\mu$ and l is a half range of the variates.

As the value of l is 10, the formula (14) may be transformed by a series of steps here omitted, to read

$$D\,n = 12.6 + 4.3 \left\{ \frac{Dcb - 29}{20} \right\} - 0.9 \left\{ \frac{Dcb - 29}{20} \right\}^2 \quad (14\text{ a})$$

Where D n = Diameter of nucleus in $\mu$.
and D c b = Diameter of cell body in $\mu$.
See table 60.

### WEIGHT OF BOTH EYEBALLS ON BODY WEIGHT (HATAI, '13, p. 112)

*Weight of both eyeballs (sexes combined)* =

$$0.000428\ Bd.\ wt. + 0.098 \log Bd.\ wt. - 0.041 \quad (15)$$

Formula (15) was used for table 144.

### WEIGHT OF HEART ON BODY WEIGHT (HATAI, '13)

*Weight of heart (sexes combined)* =

$$0.0026\ (Bd.\ wt. + 14) + 0.249 \log (Bd.\ wt. + 14) - 0.336 \quad (16)$$

Formula (16) was used for table 145.

### WEIGHT OF BOTH KIDNEYS ON BODY WEIGHT (HATAI, '13)

*Weight of both kidneys (sexes combined)* =

$$0.00718\ (Bd.\ wt. - 3) + 0.132 \log\ (Bd.\ wt. - 3) - 0.009 \qquad (17)$$

Formula (17) was used for table 145.

### WEIGHT OF LIVER ON BODY WEIGHT (HATAI, '13)

*Weight of liver (sexes combined)* =

$$0.0303\ (Bd.\ wt. + 5) + 3.340 \log\ (Bd.\ wt. + 5) - 3.896 \qquad (18)$$

$$[Bd.\ wt. > 10]$$

Formula (18) was used for obtaining the values given in table 145 for body weights of 10 grams or above. For body weights below 10 grams the weights have been determined by graphic interpolation—using the crude records as a basis.

### WEIGHT OF SPLEEN ON BODY WEIGHT (HATAI, '13)

*Weight of spleen (sexes combined)* =

$$0.00245\ Bd.\ wt. + 0.0301 \log\ (Bd.\ wt.) - 0.025 \qquad (19)$$

Formula (19) was used for table 145

### WEIGHT OF BOTH LUNGS ON BODY WEIGHT (HATAI, '13)

*Weight of both lungs (sexes combined)* =

$$0.00471\ (Bd.\ wt. + 2) + 0.122 \log\ (Bd.\ wt. + 2) - 0.056 \qquad (20)$$

Formula (20) was used for table 146.

### VOLUME OF THE BLOOD ON BODY WEIGHT (CHISOLM, '11) AND HATAI (MS '14)

$$\textit{Blood volume (sexes combined)} = \frac{Bd.\ wt.^{0.9}}{10.1} = 0.099\ (Bd.\ wt)^{0.9} \quad (21)$$

$$[5 < Bd.\ wt. < 150]$$

*Blood volume (males)* =

$$0.099\ (Bd.\ wt.)^{0.9} - 0.03 \times 0.099\ (Bd.\ wt.)^{0.9} \qquad (21\ a)$$

$$= 0.09603\ (Bd.\ wt)^{0.9}$$

$$[150 < Bd.\ wt. < 350]$$

*Blood volumes (females)* =

$$0.099\ (Bd.\ wt.)^{0.9} + 0.06 \times 0.099\ (Bd.\ wt.)^{0.9} \qquad (21\ b)$$

$$= 0.10494\ (Bd.\ wt.)^{0.9}$$

$$(150 < Bd.\ wt. < 350)$$

By using the factor 1.056 for the specific gravity of the blood corresponding formulas for the *blood weight on body weight* have been obtained as follows: Hatai (MS '14).

*Blood weight (sexes combined)* =

$$0.099\ (Bd.\ wt.)^{0.9} \times 1.056 \text{ or } = 0.1045\ (Bd.\ wt.)^{0.9} \qquad (22)$$

$$(5 < Bd.\ wt. < 150)$$

*Blood weight (males)* =

$$0.1045\ (Bd.\ wt.)^{0.9} - 0.03 \times 0.1045\ (Bd.\ wt.)^{0.9} \qquad (22\ a)$$

$$= 0.101365\ (Bd.\ wt.)^{0.9}$$

$$(150 < Bd.\ wt. < 350)$$

*Blood weight (females)* =

$$0.1045\ (Bd.\ wt.)^{0.9} + 0.06 \times 0.1045\ (Bd.\ wt.)^{0.9} \qquad (22\ b)$$

$$= 0.11077\ (Bd.\ wt)^{0.9}$$

$$(150 < Bd.\ wt. < 350)$$

These formulas (22) (22 a) and (22 b) for blood weight have been used for table 146.

### WEIGHT OF ALIMENTARY TRACT ON BODY WEIGHT (HATAI, '13)

*Weight of alimentary tract (sexes combined)* =

$$0.0245 \; Bd.\,wt. + 4.720 \log (Bd.\,wt. + 7) - 5.753 \qquad (23)$$

Formula (23) was used for table 146.

### WEIGHT OF THE STOMACH ON BODY WEIGHT (HATAI '18)

*Weight of stomach (sexes combined)* =

$$0.00375 \; Bd.\,wt. + 0.00016666 \; Bd.\,wt.^2 + 0.0073$$

$$4 < Bd.\,wt. < 20 \qquad (24)$$

$$0.00204 \; Bd.\,wt. + 0.631 \log Bd.\,wt. - 0.7130$$

$$Bd.\,wt. \overset{=}{>} 20 \qquad (24\text{ a})$$

### WEIGHT OF THE PANCREAS ON BODY WEIGHT (HATAI, '18)

In the pancreas a sex difference is distinctly shown. The pancreas in the female is heavier than in the male; consequently the growth of the pancreas in weight is treated separately according to sex and is represented by the following formulas (25), (25 a).

Some later observations by Hammett ('23) indicate that this sex relation may be reversed in certain strains.

It is evident from the limits stated that the formulas do not apply to the body weight which is less than 10 grams, and furthermore that the pancreas of the female between 10 and 20 grams in body weight is represented by the formula employed for the male rats.

### WEIGHT OF THE PANCREAS ON BODY WEIGHT (HATAI, '18)

$$\textit{Male} = 0.048 + 0.0036 \, (Bd.\,wt. - 9) + 0.09 \log (Bd.\,wt. - 9)$$

$$Bd.\,wt. \overset{=}{<} 10 \qquad (25)$$

*Female* = $10 < Bd.\,wt. < 20$ Formula (25) is used.

$$\textit{Female} = 0.00339 \; Bd.\,wt. + 0.248 \log Bd.\,wt. - 0.2091$$

$$Bd.\,wt. \overset{=}{<} 20 \qquad (25\text{ a})$$

WEIGHT OF THE SUBMAXILLARIES ON BODY WEIGHT (HATAI, '18)

*Weight of submaxillaries (2) (Males and females)*

$$= 0.00152\ (Bd.\ wt. + 5) + 0.0542\ log\ (Bd.\ wt. + 5) - 0.0524$$

$$Bd.\ wt. \leqq 5 \qquad (26)$$

WEIGHT OF BOTH TESTES ON BODY WEIGHT (HATAI, '13)

$$Wt.\ of\ testes = 0.022 - 0.00992\ Bd.\ wt. + 0.00127\ Bd.\ wt.^2 \qquad (27)$$

$$[4 < Bd.\ wt. < 10]$$

$$= 0.043 - 0.000966\ Bd.\ wt. + 0.000163\ Bd.\ wt.^2 \qquad (28)$$

$$[10 < Bd.\ wt. < 80]$$

$$= 2.910\ log\ Bd.\ wt. - 4.520 \qquad (29)$$

$$[Bd.\ wt. > 80]$$

For the weight of the testes for body weights of 4–10 grams the values were obtained by formula (27), while formulas (28) and (29) were used for obtaining the values for body weights of 10 grams or over. Formulas (27) (28) and (29) were used for table 146.

WEIGHT OF BOTH EPIDIDYMIDES—ON BODY WEIGHT (HATAI, '18)

Owing to the presence of two distinct phases of growth two formulas were used. Formula (30) for body weights up to 100 grams and formula (31) for body weights above this. Table 147.

*Weight of epididymis (2)*

$$0.003 + 0.00024\ Bd.\ wt. + 0.00002\ Bd.\ wt.^2$$

$$Bd.\ wt. \leqq 100 \qquad (30)$$

$$1.65\ log\ Bd.\ wt. - 0.000762\ Bd.\ wt. - 2.9945$$

$$Bd.\ wt. \geqq 100 \qquad (31)$$

### WEIGHT OF BOTH OVARIES ON BODY WEIGHT (HATAI, '13)

*Weight of both ovaries* =

$$= 0.00781 \; log \; Bd. \; wt. - 0.0047 \qquad (32)$$

*(Phase 1)* $[Bd.\ wt. < 65]$

$$= 0.0425 - 0.00121 \; Bd.\ wt. + 0.0000108 \; Bd.\ wt.^2 \qquad (33)$$

*(Phase 2)* $[65 < Bd.\ wt. < 110]$

$$= 0.007 \; log \; (Bd.\ wt. - 105) + 0.0352 \qquad (34)$$

*(Phase 3)* $[Bd.\ wt. > 110]$

Formulas (32) (33) (34) were used for table 146.

### WEIGHT OF HYPOPHYSIS ON BODY WEIGHT (HATAI, '13)

In the case of the hypophysis a separate formula for each sex is required.

*Weight of hypophysis (male)* =

$$0.0000257 \; (Bd.\ wt. + 3) + 0.0014 \; log \; (Bd.\ wt. + 3) - 0.00097 \qquad (35)$$

Formula (35) is also used for the female up to 50 gms. in body weight then

*Weight of hypophysis (female)* =

$$0.00205 + 0.000081 \; Bd.\ wt. - 0.00196 \; log \; (Bd.\ wt.) \qquad (36)$$

$$[Bd.\ wt. > 50]$$

Formulas (35) and (36) were used for table 148 in accordance with the restrictions indicated.

### WEIGHT OF BOTH SUPRARENALS ON BODY WEIGHT (HATAI, '13)

In the case of the suprarenals a separate formula for each sex is required.

*Weight of both suprarenals* (*male*) =

$$0.0000855\ (Bd.\ wt.\ + 3) + 0.0113\ log\ (Bd.\ wt.\ + 3)\ - 0.0093 \quad (37)$$

Formula (37) is also used for the female up to 30 gms. in body weight, then

*Weight of both suprarenals* (*female*) =

$$0.00023\ Bd.\ wt.\ + 0.00388\ log\ (Bd.\ wt.)\ - 0.002 \quad (38)$$

$$[Bd.\ wt. > 30]$$

Formulas (37) and (38) were used for table 146 in accordance with the restrictions indicated.

### WEIGHT OF THYROID ON BODY WEIGHT (HATAI, '13)

*Weight of thyroid* (*sexes combined*) =

$$0.0000973\ (Bd.\ wt. + 27) + 0.0139\ log\ (Bd.\ wt.\ + 27)\ - 0.0226 \quad (39)$$

Formula (39) was used for table 146.

### WEIGHT OF NITROGEN ON BODY WEIGHT (HATAI, '05)

To determine the amount of nitrogen eliminated by the rat during twenty-four hours at different body weights.

$$N = 10^{\frac{2.33 + (3 \times \log \text{Bd. wt.})}{4}} \quad or\ log\ N = \frac{2.33 + (3 \times log\ Bd.\ wt.)}{4} \quad (40)$$

where N = total nitrogen in milligrams and *Bd. wt.* = body weight in grams.

Formula (40) is based on the data in table 99.

## GROUP I. ALBINOS

### SECOND DIVISION: FORMULAS BASED ON AGE

### BODY WEIGHT ON AGE FROM 10–365 DAYS, HATAI (MS '14)

The formulas (41) (42) (43) (44) apply only the series of data published by Donaldson, Dunn and Watson, ('06).

*Body weight on age in days—males* =

$$11.199 + 0.0475\ Age + 0.0184\ Age^2 \tag{41}$$

$$[10 < Age < 80]$$

$$= 488 \log Age - 0.52\ Age - 678.2 \tag{42}$$

$$[80 < Age < 365]$$

*Body weight on age in days—mated females* =

$$8.071 + 0.367\ age + 0.0131\ Age^2 \tag{43}$$

$$[10 < Age < 80]$$

$$= 343 \log Age - 0.41\ Age - 498.8 \tag{44}$$

$$[80 < Age < 365]$$

Formulas (41) (42) (43) (44) were used for table 157.

### WEIGHT OF THYMUS ON AGE (HATAI, '14)

*Weight of thymus—sexes combined* =

$$0.01 \times 10^{1.1\left\{1.1884+0.5665\left(\frac{\text{age}}{55} - 1\right) - 0.5651\left(\frac{\text{age}}{55} - 1\right)^2\right\}} \tag{45}$$

$$[Age < 95]$$

*Weight of thymus* =

$$0.3903 - 0.00139\ (age) + 0.00000128\ (age)^2 \tag{46}$$

$$[Age > 95]$$

Formulas (45) (46) were used for table 151.

### PERCENTAGE OF WATER IN BRAIN (DONALDSON, '16)

The formulas do not apply to rats under ten days of age.

*Percentage of water in brain—(male)* =

$$92.122 - 0.614\ Age + 0.00739\ Age^2\ (Phase\ 1) \tag{47}$$

$$[10 < Age < 40]$$

$$= 82.756 - 2.103 \log Age \quad (Phase\ 2) \qquad (48)$$

$$[40 < Age < 160]$$

$$= 77.671 + 0.00537\ Age - 0.000016\ Age^2 \quad (Phase\ 3) \qquad (49)$$

$$[160 < Age < 365]$$

To transform any determination for the male into that for the female, the value for the male at a given age (see formulas (47) (48) (49)) is modified by a *plus* correction (Hatai).

$$Correction\ (to\ be\ added) = 0.0555 \log (age + 3) - 0.0606 \qquad (49\ a)$$

$$[10 < Age < 365]$$

The foregoing (47)–(49 a) replace the formulas given in the paper by Donaldson ('10).

Formulas (47) (48) (49) (49 a) were used for table 157.

### PERCENTAGE OF WATER IN SPINAL CORD (DONALDSON '16)

The formulas do not apply under 10 days of age. The data for the first ten days are from direct observations.

*Percentage of water in spinal cord—male* =

$$87.976 - 0.494\ Age + 0.00364\ Age^2 \quad (Phase\ 1) \qquad (50)$$

$$[10 < Age < 40]$$

$$= 100.3 + 0.0548\ Age - 17.7 \log Age \quad (Phase\ 2) \qquad (51)$$

$$[40 < Age < 150]$$

$$= 62.186 - 0.0121\ Age + 4.434 \log Age \quad (Phase\ 3) \qquad (52)$$

$$[150 < Age < 365]$$

To obtain from the values for the male at different ages the corresponding value for the female, several corrections are required and these differ according to age.

From ten to fifty days the following correction formula (52 a) is used:

$$Correction\ (to\ be\ subtracted) = 0.0006\ Age^2 - 0.036\ Age + 0.3 \qquad (52\,a)$$

The values thus obtained are subtracted from the computed values for the male at the corresponding ages.

From fifty to sixty-five days no correction is made.

From sixty-five days to one hundred and thirty-five days, correction is made according to the formula (52 b).

$$\textit{Correction (to be added)} = 0.823 \log (Age + 1) - 0.000542 (Age + 1) - 1.4616 \qquad (52\ b)$$

From one hundred and thirty-five to one hundred and sixty-five days the correction is uniform thus:

$$\textit{Correction (to be added)} = 0.22 \qquad (52\ c)$$

From one hundred and sixty-five to three hundred and sixty-five days correction is made by the following formula:

$$\textit{Correction (to be added)} = 0.22 + 0.0005 (Age - 165) \qquad (52\ d)$$

The foregoing (50)–(52 d) replace the formulas given in the paper by Donaldson, '10.

Formulas (50)–(52 d) were used for table 157.

## GROUP II. NORWAYS

### FIRST DIVISION: FORMULAS BASED ON SIZE

### BODY LENGTH ON BODY WEIGHT—NORWAY (DONALDSON AND HATAI, '11)

$$\textit{Body length (sexes combined)} = 159 \log (Bd.\ wt. + 18) - 165 \qquad (53)$$

The body length for the male is 0.4 per cent above the value given by formula (53) and that for the female 0.4 per cent below. Formula (53) with above corrections was used for graphs in chart 61.

### BODY WEIGHT ON BODY LENGTH (DONALDSON AND HATAI, '11)

By transforming formula (53) and introducing the correction for sex we obtain:

(1) For the male

$$\textit{Body weight} = 10^{0.0000629\ (Bd.\ l. \times 100 - [(Bd.\ l. \times 100 \times 0.004] + 16500)} - 18 \qquad (54)$$

$$= 10^{0.0000629\ (Bd.\ l. \times 99.6 + 16500)} - 18$$

(2) For the female

$$\textit{Body weight} = 10^{0.0000629\ (Bd.\ l. \times 100 + [(Bd.\ l. \times 100 \times 0.004 + 16500)} - 18 \qquad (55)$$

$$= 10^{0.0000629\ (Bd.\ l. \times 100.4 + 16500)} - 18$$

Formulas (54) (55) were used for table 187.

### Tail Length on Body Length, Norway (Hatai, ms '14)

(1) For the male

$$\textit{Tail length} = 0.824\ Bd.\ l. + 39.1\ (log.\ Bd.\ l.) - 92.6 \qquad (56)$$

(2) For the female.

$$\textit{Tail length} = 0.824\ Bd.\ l. + 43.1\ log\ (Bd.\ l.) - 98.4 \qquad (57)$$

Formulas (56) (57) were used for table 187.

### Brain Weight on Body Weight, Norway (Donaldson and Hatai, '11)

*Brain weight* (*sexes combined*)

$$= 0.825\ log\ (Bd.\ wt. - 4) + 0.233 \qquad (58)$$

This formula applies only to rats 5 grams or more in body weight. To obtain the weights for the male the values given by the formula are increased by 1 per cent, and to obtain the weights for the female, they are decreased by 1 per cent.

Formula (58) with corrections mentioned above was used for table 187.

### Cranial Capacity on Body Weight, Norway (Donaldson, '12)

*Cranial capacity in cc.* (*sexes combined*) =

$$0.00105\ Bd.\ wt. + 0.548\ log\ Bd.\ wt. + 0.476 \qquad (59)$$

$$[80 < Bd.\ wt. < 380]$$

### Spinal Cord Weight on Body Weight, Norway (Donaldson and Hatai, '11)

*Spinal cord weight (sexes combined)* =

$$0.724 \log (Bd.\,wt. + 30) - 1.082 \qquad (60)$$

To obtain the weights for the male the values given by the formula are increased by 0.15 per cent, and to obtain the weights for the female they are decreased by 0.15 per cent.

Formula (60) with corrections mentioned above was used for table 187.

### Spinal Cord Weight on Brain Weight (Sexes Combined), Norway (Donaldson and Hatai '11)

$$Spinal\ cord\ wt. = 0.724 \log \left(10^{\frac{Br.\,wt. - 0.233}{0.825}} + 34\right) - 1.082 \qquad (61)$$

For the Norway we have no extensive data based on age—hence there are no formulas based on age.

## GROWTH OF PARTS AND ORGANS IN RELATION TO BODY LENGTH AND IN RELATION TO AGE: REFERENCES

*Introduction.* Chisolm, '11. Donaldson and Conrow, '19, Sugita, '17.

*Body length relations.* Donaldson, '06, '09. Donaldson and Hatai, '11. Ferry, '13.

*Body length on body weight.* Donaldson, '09. Donaldson and Hatai, '11.

*Body weight on body length.* Donaldson, '09. Donaldson and Hatai, '11. Jackson and Lowrey, '12.

*Tail length on body length.* Przibram, '22 a, '22 b, '22 c, '22 d. Przibram and Wiesner, '22. Przibram, '23.

*Organs with early rapid growth—Brain, cord, eyes.* Donaldson, '08, '09, '11, '11 c. Donaldson and Hatai, '11 a. Donaldson, '12. Donaldson, Hatai and King, '15. Donaldson, '17, '18, '18 a. Donaldson and Nagasaka, '18. Hatai '07 a, '08, '09 a, '13 a. Jackson, '13. Watson, '05. Ziehen, '06.

*Weight of parts of brain.* Hatai, '13. Jackson, '13. Stewart, '18 a. Sugita, '17.

*Organs with a nearly uniform growth.* Chisolm, '11. Degener, '22. Hatai, '13, '14 a, '18. Jackson, '13. Jolly and Stini, '05. Kittelson, '17, '20. Rous and McMaster, '24.

*Organs with a sinuous graph of growth.* Hatai, '13, '14, '14 a, '18. Jackson, '13.

*Variability.* Jackson, '13.

*Entire body on age. Prenatal.* Stotsenburg, '15. *Postnatal.* Donaldson, '06. Greenman and Duhring, '23. Hatai, '03 a, '04 a, '23.

*Weight of thymus on age.* Hatai, '14.

*Weight of viscera.* Jackson and Lowrey, '12.

*Relative weights of individual viscera.* Donaldson, '23 b.

*Formulas.* Chisolm, '11. Donaldson, '08, '09. Donaldson and Hatai, '11. Donaldson, '12, '16. Hatai, '05, '07 b, '07 c, '09 a, '10, '10 a, '11, '13, '14, '18.

# CHAPTER 8

# GROWTH IN TERMS OF WATER AND SOLIDS

1. In the body as a whole. 2. In the larger divisions of the body and the organs. 3. In the brain and spinal cord. 4. Corrections.

1. *In the body as a whole.* 2. *In the larger divisions of the body and the organs.* Data on this head have been published by Lowrey ('13) and are here presented.

With the exception of one of the old rats the animals used for table 158 were reared at the University of Missouri. They were fed on chopped corn with a daily ration of bread soaked in whole milk and once a week a small quantity of fresh beef was given them. All were sound except some of the older animals which suffered from infected lungs—but not to such a degree as to affect their general nutrition of vigor. Table 158 is based on table 1, Lowrey ('13). The data for the two sexes are combined. In the original the range of the observations is given and also the number of animals used in each instance. In the present table the ranges are omitted and the number of animals is given for the body weight (net) only. The other determinations for the systems and organs were based on about the same number of animals as were used for the body weight, except in the case of testes where the numbers are about half as large. The oldest animals were somewhat under one year of age.

In table 158 the percentage data are given for the dry substance. Here in table 159 they are transformed to the percentage of water.

To supplement table 159 the graphs in chart 50 show the relations of the percentage of dry substance in the entire body and its principal parts.

The growth of dry substance is most marked during the active growing period, from birth to 75–100 days.

TABLE 158

*Giving the percentage weight of the dry substance in the integument, skeleton (ligamentous), musculature, viscera and remainder in terms of the dry substance of the entire body, Lowrey '13.*

| AGE IN DAYS | NUMBER OF ANIMALS | ABSOLUTE WEIGHT OF DRY SUBSTANCE ENTIRE BODY* | PERCENTAGE WEIGHT OF DRY SUBSTANCE OF ENTIRE BODY REPRESENTED BY | | | | |
|---|---|---|---|---|---|---|---|
| | | | Skin | Skeleton (ligamentous) | Musculature | Viscera | Remainder |
| 0...... | 7 | 0.494 | 21.2 | 24.3 | 23.8 | 22.5 | 8.1 |
| 7...... | 10† | 1.830 | 27.9 | 20.2 | 18.2 | 13.9 | 19.9 |
| 20...... | 9 | 7.320 | 28.3 | 18.7 | 19.6 | 13.0 | 20.4 |
| 42...... | 10 | 17.300 | 24.0 | 19.8 | 26.0 | 14.6 | 15.6 |
| 70...... | 7† | 42.400 | 23.3 | 16.3 | 30.0 | 12.1 | 18.3 |
| 150...... | 10 | 60.600 | 23.4 | 17.1 | 31.7 | 11.8 | 16.0 |
| 365 (?).. | 2 | 84.300 | 22.9 | 17.5 | 35.3 | 9.4 | 14.9 |

* The fresh weights at the several ages are those given under body weight (net) table 159.

† Skeleton and musculature not separately determined in one instance.

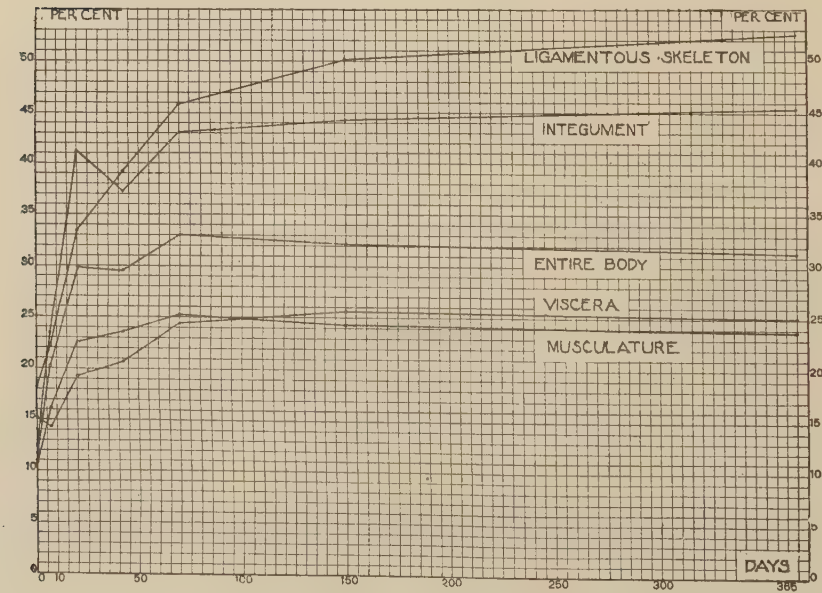

Chart 50 Giving the percentage of dry substance in the body as a whole and in the several systems at different ages. Lowrey ('13).

(*a*) *Percentage of water in the cartilaginous skeleton and its parts* (*Donaldson and Conrow, '19*). The data are presented in tables 160–163 and in charts 51–54.

The observations of Lowrey, just cited, give the percentage of water in the ligamentous skeleton. It is desirable however to present the corresponding observations on the cartilaginous skeleton, where the soft parts are more completely removed, taking account at the same time of the modification of the percentage of water produced by the macerating fluid which was used.

TABLE 159

*Percentages of water in the entire body—in several of the systems and in some organs. Observations at seven ages. See Chart 50.*

| AGE IN DAYS | BODY (NET) | | | INTEGUMENT | | LIGAMENTOUS SKELETON | | MUSCULATURE | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of animals | Average fresh weight | Average per cent of water | Average fresh weight | Average per cent of water | Average fresh weight | Average per cent of water | Average fresh weight | Average per cent of water |
| | | *grams* | | *grams* | | *grams* | | *grams* | |
| 0..... | 15 | 4.200 | 88.3 | 0.880 | 87.7 | 0.660 | 81.9 | 1.100 | 89.3 |
| 7..... | 10 | 9.100 | 79.9 | 2.180 | 76.6 | 1.710 | 77.9 | 2.020 | 83.8 |
| 20..... | 9 | 24.500 | 70.1 | 5.020 | 58.9 | 4.090 | 66.7 | 6.400 | 77.4 |
| 42..... | 10 | 61.300 | 70.5 | 11.040 | 62.9 | 8.610 | 60.8 | 18.730 | 76.5 |
| 70..... | 7 | 126.700 | 67.0 | 20.020 | 57.0 | 14.840 | 54.1 | 51.500 | 74.8 |
| 150..... | 10 | 182.400 | 67.8 | 32.200 | 55.8 | 20.020 | 49.6 | 76.920 | 75.7 |
| 365 (?). | 2 | 267.500 | 68.5 | 37.780 | 54.5 | 23.180 | 47.4 | 125.000 | 76.2 |
| | | ALL VISCERA* | | EYEBALLS | | HEART | | LUNGS | |
| 0..... | | 0.780 | 84.8 | 0.023 | 92.6 | 0.025 | 86.2 | 0.077 | 81.4 |
| 7..... | | 1.760 | 85.8 | 0.066 | 89.6 | 0.061 | 85.6 | 0.169 | 84.2 |
| 20..... | | 5.090 | 80.9 | 0.110 | 85.6 | 0.135 | 82.0 | 0.236 | 81.1 |
| 42..... | | 12.170 | 79.3 | 0.162 | 84.7 | 0.412 | 79.0 | 0.404 | 80.9 |
| 70..... | | 20.900 | 75.6 | 0.207 | 83.0 | 0.625 | 78.4 | 0.791 | 80.8 |
| 150..... | | 26.570 | 74.4 | 0.279 | 81.0 | 0.714 | 78.8 | 1.354 | 81.0 |
| 365 (?). | | 31.750 | 74.9 | 0.340 | 79.8 | 0.934 | 77.6 | 2.806 | 81.6 |
| | | LIVER | | SPLEEN | | KIDNEYS | | TESTES | |
| 0..... | | 0.234 | 80.6 | | | 0.038 | 86.7 | | |
| 7..... | | 0.307 | 79.4 | 0.041 | 85.7 | 0.123 | 85.5 | | |
| 20..... | | 1.200 | 75.7 | 0.076 | 82.8 | 0.322 | 82.8 | 0.106 | 87.1 |
| 42..... | | 3.541 | 75.8 | 0.273 | 80.2 | 0.832 | 79.7 | 0.568 | 86.7 |
| 70..... | | 6.617 | 74.5 | 0.588 | 79.9 | 1.320 | 79.2 | 1.653 | 87.6 |
| 150..... | | 9.236 | 74.3 | 0.666 | 79.4 | 1.728 | 78.0 | 2.425 | 87.8 |
| 365 (?). | | 9.959 | 74.0 | 0.722 | 77.4 | 2.294 | 77.1 | 2.044 | 87.0 |

* "All viscera" comprises the series of organs used by Jackson and Lowrey ('12). See note 9, page 264.

TABLE 160

*A. Percentage of water in oven-dried entire skeleton on age in days. B. Percentage of water in oven-dried entire skeleton and appendicular skeleton, on body weight. Values taken from the smoothed graphs in chart 51.*

| AGE | A | B | | |
|---|---|---|---|---|
| | Percentage of water-skeleton | Body weight | Percentage of water-skeleton | Percentage of water-appendicular skeleton |
| *days* | | *grams* | *per cent* | *per cent* |
| 0 | 79.2 | 5 | 79.1 | 79.1 |
| 5 | 77.0 | 10 | 76.0 | 76.0 |
| 10 | 73.5 | 15 | 72.4 | 72.0 |
| 15 | 69.6 | 20 | 69.0 | 67.1 |
| 20 | 66.0 | 25 | 65.4 | 64.0 |
| 25 | 62.0 | 30 | 63.1 | 62.2 |
| 30 | 58.0 | 35 | 61.2 | 60.4 |
| 35 | 54.4 | 40 | 59.1 | 58.6 |
| 40 | 52.4 | 45 | 57.1 | 56.8 |
| 45 | 50.8 | 50 | 55.2 | 55.0 |
| 50 | 49.0 | 55 | 53.2 | 53.2 |
| 55 | 47.2 | 60 | 52.0 | 52.0 |
| 60 | 46.0 | 65 | 50.7 | 50.6 |
| 65 | 44.8 | 70 | 49.4 | 49.1 |
| 70 | 43.8 | 75 | 48.1 | 48.0 |
| 75 | 42.8 | 80 | 46.8 | 46.6 |
| 80 | 41.8 | 85 | 45.6 | 45.2 |
| 85 | 40.8 | 90 | 44.4 | 44.0 |
| 90 | 40.0 | 95 | 43.1 | 42.5 |
| 95 | 38.8 | 100 | 41.8 | 41.2 |
| 100 | 38.2 | 110 | 39.4 | 38.8 |
| 110 | 37.9 | 120 | 38.8 | 37.0 |
| 120 | 37.6 | 130 | 38.4 | 35.3 |
| 130 | 37.4 | 140 | 38.1 | 34.8 |
| 140 | 37.2 | 150 | 37.9 | 34.2 |
| 150 | 36.9 | 160 | 37.6 | 33.7 |
| 160 | 36.7 | 170 | 37.4 | 33.2 |
| 170 | 36.5 | 180 | 37.1 | 32.6 |
| 180 | 36.2 | 190 | 36.8 | 32.1 |
| 190 | 36.0 | 200 | 36.6 | 31.6 |
| 200 | 35.9 | 230 | 35.6 | 31.1 |
| 230 | 35.2 | 260 | 35.1 | 30.7 |
| 260 | 35.1 | 290 | 34.9 | 30.3 |
| 290 | 34.9 | 320 | 34.7 | 30.1 |
| 320 | 34.7 | 350 | 34.5 | 29.6 |
| 350 | 34.5 | 380 | 34.2 | 29.2 |
| 380 | 34.2 | 410 | 34.1 | 28.7 |
| 410 | 34.1 | 440 | 34.0 | 28.3 |
| 440 | 34.0 | 480 | 33.6 | 28.0 |
| 480 | 33.6 | | | |

TABLE 161

*Percentage of water in oven-dried cranium and vertebrae, on body weight. Values taken from the smoothed graphs in chart 52.*

| BODY WEIGHT | CRANIUM | VERTEBRAE |
|---|---|---|
| *grams* | *per cent* | *per cent* |
| 5 | 80.1 | 80.1 |
| 10 | 76.8 | 76.8 |
| 15 | 72.4 | 70.5 |
| 20 | 68.4 | 68.4 |
| 25 | 64.0 | 66.8 |
| 30 | 60.4 | 65.1 |
| 35 | 58.2 | 63.4 |
| 40 | 56.3 | 61.8 |
| 45 | 54.8 | 60.0 |
| 50 | 53.1 | 58.4 |
| 55 | 52.0 | 56.8 |
| 60 | 51.0 | 54.8 |
| 65 | 50.1 | 53.6 |
| 70 | 49.2 | 52.1 |
| 75 | 48.3 | 50.5 |
| 80 | 47.4 | 49.4 |
| 85 | 46.4 | 48.1 |
| 90 | 45.6 | 47.1 |
| 95 | 44.8 | 46.0 |
| 100 | 44.0 | 44.8 |
| 110 | 43.4 | 42.0 |
| 120 | 43.2 | 39.6 |
| 130 | 42.9 | 38.2 |
| 140 | 42.7 | 38.0 |
| 150 | 42.4 | 38.0 |
| 160 | 42.2 | 37.9 |
| 170 | 42.1 | 37.7 |
| 180 | 42.0 | 37.5 |
| 190 | 42.0 | 37.4 |
| 200 | 41.8 | 37.3 |
| 210 | 41.6 | 37.2 |
| 220 | 41.4 | 37.0 |
| 230 | 41.3 | 36.9 |
| 240 | 41.2 | 36.8 |
| 250 | 41.2 | 36.7 |
| 270 | 41.0 | 36.4 |
| 290 | 40.8 | 36.1 |
| 310 | 40.5 | 36.0 |
| 330 | 40.2 | 35.6 |
| 350 | 40.1 | 35.4 |
| 370 | 40.0 | 35.1 |
| 390 | 39.7 | 34.8 |
| 410 | 39.5 | 34.5 |
| 430 | 39.3 | 34.2 |
| 450 | 39.1 | 33.8 |
| 470 | 38.8 | 33.4 |
| 485 | 38.7 | 33.1 |

## TABLE 162

*Percentage of water in oven-dried humerus, ulna plus radius, and bones of fore feet, on body weight. Values taken from the smoothed graphs in chart 53.*

| BODY-WEIGHT | HUMERUS (2) | ULNA PLUS RADIUS (2) | BOTH FORE FEET |
|---|---|---|---|
| *grams* | *per cent* | *per cent* | *per cent* |
| 5 | 79.8 | 73.8 | 80.1 |
| 10 | 75.8 | 70.0 | 74.0 |
| 15 | 72.2 | 66.0 | 68.0 |
| 20 | 69.1 | 62.8 | 61.2 |
| 25 | 66.3 | 60.1 | 58.4 |
| 30 | 64.5 | 57.4 | 56.0 |
| 35 | 62.7 | 54.8 | 53.8 |
| 40 | 60.8 | 52.4 | 51.6 |
| 45 | 58.9 | 50.4 | 49.2 |
| 50 | 57.0 | 48.2 | 47.0 |
| 55 | 55.2 | 46.0 | 44.8 |
| 60 | 54.0 | 43.9 | 42.4 |
| 65 | 52.8 | 41.8 | 40.1 |
| 70 | 51.6 | 39.5 | 38.0 |
| 75 | 50.4 | 37.8 | 36.0 |
| 80 | 49.2 | 36.7 | 34.6 |
| 85 | 48.1 | 35.6 | 33.2 |
| 90 | 46.8 | 34.3 | 31.8 |
| 95 | 45.6 | 33.1 | 30.4 |
| 100 | 44.4 | 32.0 | 28.8 |
| 110 | 42.2 | 29.7 | 26.8 |
| 120 | 40.6 | 28.3 | 26.0 |
| 130 | 39.0 | 27.3 | 25.0 |
| 140 | 37.6 | 26.3 | 24.1 |
| 150 | 37.3 | 25.3 | 23.4 |
| 160 | 37.0 | 25.0 | 22.9 |
| 170 | 36.6 | 24.6 | 22.5 |
| 180 | 36.2 | 24.3 | 22.1 |
| 190 | 36.0 | 24.0 | 22.0 |
| 200 | 35.6 | 23.6 | 21.6 |
| 210 | 35.2 | 23.2 | 21.2 |
| 220 | 34.8 | 22.9 | 20.9 |
| 230 | 34.6 | 22.7 | 20.6 |
| 240 | 34.2 | 22.5 | 20.4 |
| 250 | 34.1 | 22.3 | 20.1 |
| 270 | 34.0 | 22.0 | 19.9 |
| 290 | 33.7 | 21.7 | 19.5 |
| 310 | 33.4 | 21.3 | 19.4 |
| 330 | 33.2 | 20.9 | 19.3 |
| 350 | 33.0 | 20.5 | 19.2 |
| 370 | 32.7 | 20.2 | 19.2 |
| 390 | 32.5 | 19.9 | 19.1 |
| 410 | 32.2 | 19.5 | 19.0 |
| 430 | 32.0 | 19.2 | 18.9 |
| 450 | 31.9 | 18.7 | 18.8 |
| 470 | 31.6 | 18.3 | 18.8 |
| 485 | 31.4 | 18.0 | 18.8 |

### TABLE 163

*Percentage of water in oven-dried femur, tibia plus fibula, and bones of hind feet, on body weight. Values taken from the smoothed graphs, in chart 54.*

| BODY WEIGHT | FEMUR (2) | TIBIA PLUS FIBULA (2) | BOTH HIND FEET |
|---|---|---|---|
| *grams* | *per cent* | *per cent* | *per cent* |
| 5 | 80.7 | 76.6 | 83.2 |
| 10 | 77.2 | 73.4 | 77.2 |
| 15 | 74.0 | 70.1 | 72.4 |
| 20 | 71.1 | 66.8 | 67.8 |
| 25 | 69.2 | 64.4 | 64.4 |
| 30 | 67.6 | 62.4 | 60.4 |
| 35 | 65.8 | 60.6 | 58.1 |
| 40 | 64.0 | 58.8 | 56.0 |
| 45 | 62.2 | 56.8 | 54.0 |
| 50 | 60.4 | 55.1 | 51.9 |
| 55 | 58.6 | 53.2 | 49.8 |
| 60 | 57.3 | 51.4 | 47.6 |
| 65 | 56.0 | 50.2 | 45.0 |
| 70 | 54.8 | 49.2 | 43.2 |
| 75 | 53.4 | 48.1 | 41.2 |
| 80 | 52.1 | 47.0 | 39.4 |
| 85 | 50.9 | 46.0 | 37.6 |
| 90 | 49.6 | 44.8 | 35.8 |
| 95 | 48.2 | 43.6 | 33.8 |
| 100 | 47.0 | 42.4 | 32.0 |
| 110 | 45.2 | 40.4 | 28.4 |
| 120 | 43.8 | 38.4 | 26.7 |
| 130 | 42.4 | 36.8 | 26.0 |
| 140 | 40.9 | 35.6 | 25.2 |
| 150 | 40.2 | 34.9 | 24.8 |
| 160 | 39.5 | 34.1 | 24.1 |
| 170 | 38.8 | 33.3 | 23.2 |
| 180 | 38.4 | 32.5 | 22.5 |
| 190 | 38.1 | 32.2 | 22.2 |
| 200 | 37.9 | 32.1 | 21.9 |
| 210 | 37.6 | 32.0 | 21.5 |
| 220 | 37.5 | 31.9 | 21.1 |
| 230 | 37.3 | 31.7 | 20.7 |
| 240 | 37.2 | 31.6 | 20.4 |
| 250 | 37.2 | 31.4 | 20.1 |
| 270 | 36.9 | 31.2 | 19.6 |
| 290 | 36.6 | 30.9 | 19.3 |
| 310 | 36.4 | 30.6 | 19.2 |
| 330 | 36.1 | 30.3 | 19.1 |
| 350 | 36.0 | 30.1 | 19.0 |
| 370 | 35.7 | 29.9 | 18.9 |
| 390 | 35.4 | 29.5 | 18.8 |
| 410 | 35.2 | 29.2 | 18.8 |
| 430 | 35.0 | 28.9 | 18.6 |
| 450 | 34.8 | 28.8 | 18.5 |
| 470 | 34.5 | 28.4 | 18.4 |
| 485 | 34.4 | 28.1 | 18.4 |

No attempt is made to harmonize in detail these two series of values but the correction coefficients for reducing the observed values in the macerated cartilaginous skeleton to the true values are given in table 127.

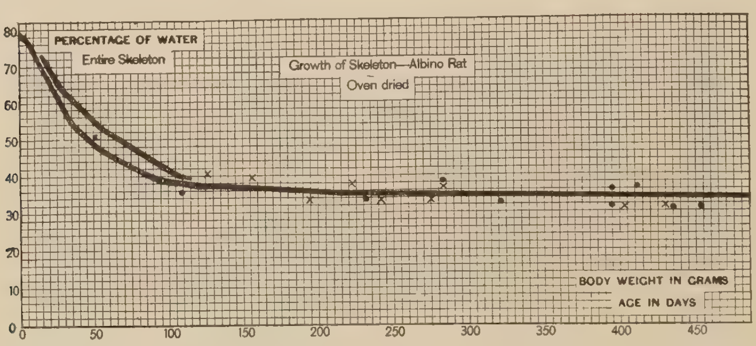

Chart 51 Percentage of water in the entire skeleton—oven dried—on age and on body weight (albino rat). Table 160.
• Age. × Body weight.

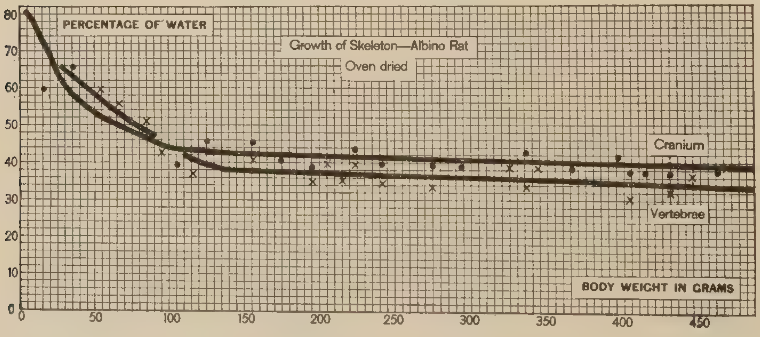

Chart 52 Percentage of water in the oven-dried cranium and in the vertebrae, on body weight (albino rat). Table 161.
• Cranium. × Vertebrae.

Examination of the tables giving the percentages of water in the different bones shows considerable differences especially after the early stages. These differences appear to be related to differences in the density of the osseous tissue and to the presence of cavities, as in the humerus and femur.

(*b*) *Correction for the percentage of water after maceration.* At birth the oven-dried macerated bones show 0.6 per cent less water than those mechanically cleaned. This deficiency increases at the rate of 0.04 per cent for each 5 grams in body weight up

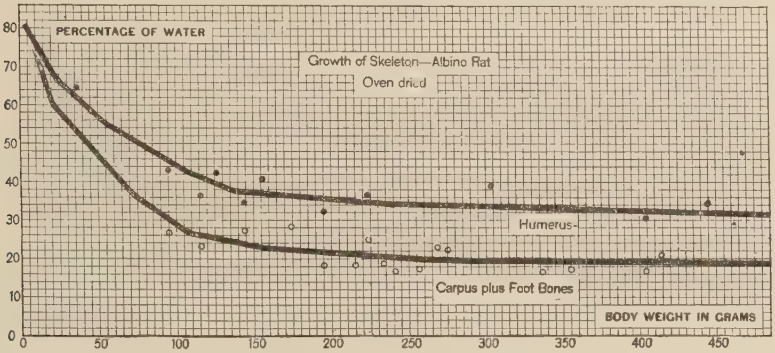

Chart 53 Percentage of water in the oven-dried bones of fore limb, on body weight (albino rat). Table 162.
• Humerus. ○ Carpus plus foot bones. The graph for the ulna plus radius coincides nearly with that for the carpus, and is therefore omitted.

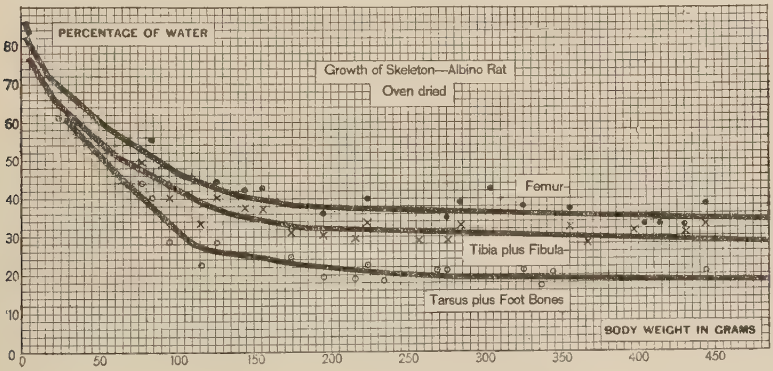

Chart 54 Percentage of water in the oven-dried bones of hind limb, on body weight (albino rat). Table 163.
• Femur. × Tibia and fibula. ○ Tarsus and foot bones.

to 150 grams. At this body weight it amounts to 1.8 per cent and this deficiency persists in the heavier rats. The true percentage of water can therefore be approximated by applying these corrections to the values in the tables.

*On the percentage value of the loss in weight on passing from the room dried to the oven dried condition.* In general the loss of water in passing from the room-dried to the oven-dried state is about 8.3 per cent of the room-dried value, and the oven-dried weight is therefore 91.7 per cent of the room-dried. Table 164 gives the several values, according to the part of the skeleton, as determined for the four body-weight groups which have been selected.

3. *Percentage of water in the brain and spinal cord.* Using stock rats from the colony at The Institute, the percentage of water has been determined for the brain and spinal cord by Donaldson ('16). The values obtained by this study replace those previously published (Donaldson '10). The methods of removal are given on page 206. The rats were reared on a scrap diet. The fresh brain or cord was weighed in a closed bottle, then dried at 90°–95°C. until the dried weight was constant—and the difference taken as the amount of water.

TABLE 164

*The percentage in weight lost by room-dried bones after oven drying at 96°C. Based on the averages of the percentages as determined for each of the forty-two groups*

| | ENTRIES 1–6, BODY WEIGHT 4–50 | ENTRIES 7–12, BODY WEIGHT 50–100 | ENTRIES 13–28, BODY WEIGHT 100–300 | ENTRIES 29–42, BODY WEIGHT 300–500 | AVERAGE FOR ALL BODY WEIGHTS |
|---|---|---|---|---|---|
| | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| Entire skeleton | 8.38 | 8.26 | 8.38 | 8.35 | 8.34 |
| Axial skeleton | 8.24 | 8.62 | 8.23 | 8.38 | 8.37 |
| Appendicular skeleton | 8.64 | 7.79 | 8.45 | 8.26 | 8.28 |
| Shoulder girdle and fore limbs | 9.74 | 8.10 | 8.35 | 8.13 | 8.58 |
| Pelvic girdle and hind limbs | 8.67 | 7.77 | 8.55 | 8.40 | 8.35 |
| Cranium with teeth | 8.64 | 9.13 | 8.83 | 8.89 | 8.87 |
| Humerus (2) | 8.33 | 7.54 | 8.33 | 8.19 | 8.10 |
| Ulna and radius (2) | 8.33 | 7.72 | 8.24 | 8.17 | 8.11 |
| Femur (2) | 7.89 | 7.60 | 8.48 | 8.48 | 8.11 |
| Tibia and fibula (2) | 7.65 | 7.75 | 8.55 | 8.17 | 8.00 |

By the use of formulas (47)–(49a) for the brain and formulas (50)–(52d) for the spinal cord, the values for table 157 after 10 days of age, were obtained and also those for the respective graphs in chart 55. The data for the first 10 days are from direct observations. The percentage of water in the brain and spinal cord is linked with age and is not readily modified by nutritive conditions, nevertheless lung disease tends to lower the percentage of water in both the brain and the cord. King ('11). Degener ('22).

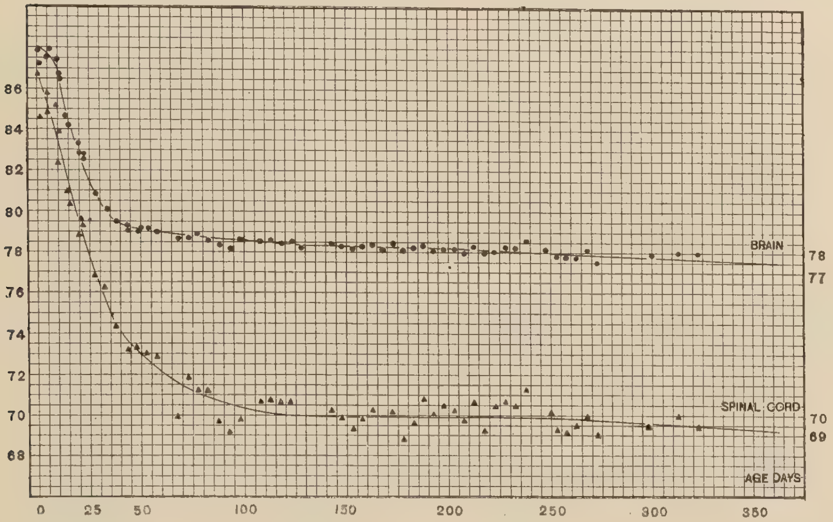

Chart 55 Showing the percentage of water on age in the central nervous system of the male albino rat. The upper graph gives the values for the water in the brain as determined by the formulas (Hatai—in 'The Rat,' Donaldson, 1915). The lower graph gives the corresponding values for the spinal cord determined in the same way. The small black dots indicate for the brain the corrected (observed) values for the several age groups, and these corrected values form the data on which the formulas have been based. The small black triangles have a like significance in relation to the spinal cord, (Donaldson '16). Formulas: Brain: (47)–(49 a), spinal cord: (50)–(52 d). Table 157.

4. *Correction for the percentage of water according to the absolute brain weight in each sex. Body weight normal to age.* Brains low in weight for the body weight on age (as shown in table 157) tend to have a *higher* percentage of water than appears there. Similarly, brains high in weight tend to have a *lower* percentage of water. When using table 157 for reference, correction may be made for the absolute brain weight at a given age when this

weight deviates from the table value. The correction factor is the same for both sexes and for a difference + or − of 0.001 gram in brain weight is respectively − or + 0.0013 per cent of water. The computed correction for the percentage of water is added to the table value in the case of a small (light) brain and subtracted in the case of a large (heavy) brain. These corrections do not apply to brains from rats less than 20 days of age, nor to excessive differences (more than ± 15 per cent) in brain weight. By the same procedure correction may be made for the percentage of water in the spinal cord according to its absolute weight. Table 165 gives the factors to be used.

*Body weight not normal to age.* Finally there is the not infrequent instance of body weights which depart widely from those for given ages in table 157. Where this departure is in excess the absolute brain weight is that to be expected for the body weight. In this instance the percentage of water in the brain or cord characteristic for the age is to be taken as the basal value and corrected according to the deviation in the weight of the brain or cord by the use of the respective correction factors given under "Body weight normal to age."

TABLE 165

*Albino rat. Change in the percentage of water for each 0.001 gram of spinal cord weight as obtained from the comparison of the light and heavy cords in the same age group*

| PHASE | AGE IN DAYS | CORRECTION FACTOR | |
|---|---|---|---|
| | | Males | Females |
| 1 | 10–58 | 0.010 | 0.008 |
| 2 | 58–365 | 0.009 | 0.007 |

A corresponding procedure applies in the case of rats with body weights low for age.

*Correction according to sex.* According to table 157 after 28 days of age the brain—and after 62 days the spinal cord also, weigh less in the female than in the male of like age.

When a comparison of the respective percentages of water is made after these limiting ages it is found that this is higher in both the brain and the cord of the female.

In this instance therefore the smaller nervous system (of the female) at a given age has a somewhat higher percentage of water, thus agreeing with the relations found between the small and large nervous systems within each sex at body weights normal to age.

Taking the male as the standard the relations found for the female are

Brain weight −0.001 gram = + 0.001 percentage of water
Spinal cord weight −0.001 gram = + 0.008 percentage of water

As will be noted these values are close to those for the correction factors within each sex.

## GROWTH IN TERMS OF WATER AND SOLIDS: REFERENCES

*In the body as a whole.* Lowrey, '13. Hatai, '17.

*In the larger divisions.* Lowrey, '13.

*In Skeleton.* Donaldson and Conrow, '19. Lowrey, '13.

*In brain and spinal cord. Corrections and correction factors.* Cavazzani and Muzzioli, '12. Donaldson, '10, '11 a, '11 b, '16, '16 a, '16 b. King, '11. Weisbach, 1868.

# CHAPTER 9

## GROWTH OF CHEMICAL CONSTITUENTS

1. In the body as a whole. 2. Osseous system. 3. In the nervous system.

1. *In the body as a whole.* For the body as a whole Hatai ('17) has made a determination of its composition in terms of proteins, fat, organic extract and salts, at eight ages. The results are given in table 166 and Chart 56.

TABLE 166

*Giving the chemical composition of the albino rat—Hatai ('17)*

| | AGE IN DAYS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Birth | 7 | 15 | 22 | 28 | 35 | 42 | 294 |
| Body, grams | 4.3 | 10.2 | 13.5 | 24.9 | 47.3 | 52.5 | 65.8 | 277.5 |
| Water, per cent | 87.2 | 79.8 | 72.9 | 70.6 | 69.6 | 70.6 | 69.4 | 65.3 |
| Solids, grams | 0.6 | 2.1 | 3.7 | 7.3 | 14.4 | 15.5 | 20.1 | 96.4 |
| Percentages of solids | 12.8 | 20.2 | 27.1 | 29.4 | 30.4 | 29.4 | 30.6 | 34.7 |
| Percentage of solids in | | | | | | | | |
| Residue | 56.9 | 42.0 | 39.9 | 38.8 | 38.6 | 44.9 | 44.4 | 44.5 |
| Per cent of moist weight | 7.3 | 8.5 | 10.8 | 11.4 | 11.7 | 13.2 | 13.6 | 15.5 |
| Fat | 14.2 | 35.4 | 39.2 | 36.6 | 37.7 | 25.9 | 27.1 | 16.5 |
| Per cent of moist weight | 1.8 | 7.2 | 10.6 | 10.8 | 11.5 | 7.6 | 8.3 | 5.7 |
| Organic extract | 16.4 | 12.8 | 12.8 | 14.8 | 13.8 | 18.6 | 16.9 | 28.2 |
| Per cent of moist weight | 2.1 | 2.6 | 3.5 | 4.3 | 4.2 | 5.5 | 5.2 | 9.8 |
| Soluble salts | 6.6 | 4.6 | 3.0 | 3.2 | 3.3 | 1.5 | 2.7 | 2.5 |
| Per cent of moist weight | 0.8 | 0.9 | 0.8 | 0.9 | 1.0 | 0.4 | 0.8 | 0.8 |
| Fixed salts | 5.9 | 5.2 | 5.2 | 6.7 | 6.5 | 9.2 | 8.9 | 8.3 |
| Per cent of moist weight | 0.7 | 1.0 | 1.4 | 2.0 | 2.0 | 2.7 | 2.7 | 2.9 |

The following paragraphs define the terms used in table 166.

*Residue.* The residue is represented by the solids from which all the organic substances soluble in both boiling alcohol and in water, as well as the salts have been removed. Thus the residue as here defined represents practically all the protein substances.

*Fat.* Fat is represented by the substances soluble in boiling alcohol from which the water soluble organic extractives and salts have been removed.

*Organic extractives.* All water soluble substances from which the salts were removed are called the organic extractives.

*Soluble salts.* The salts here designated were obtained from all the extractives with both water and alcohol.

*Fixed salts.* The solids from which fat, organic extractives and soluble salts had been removed were incinerated and the ash thus obtained is here called the fixed salts. Thus these fixed salts are practically all salts present in the osseous system.

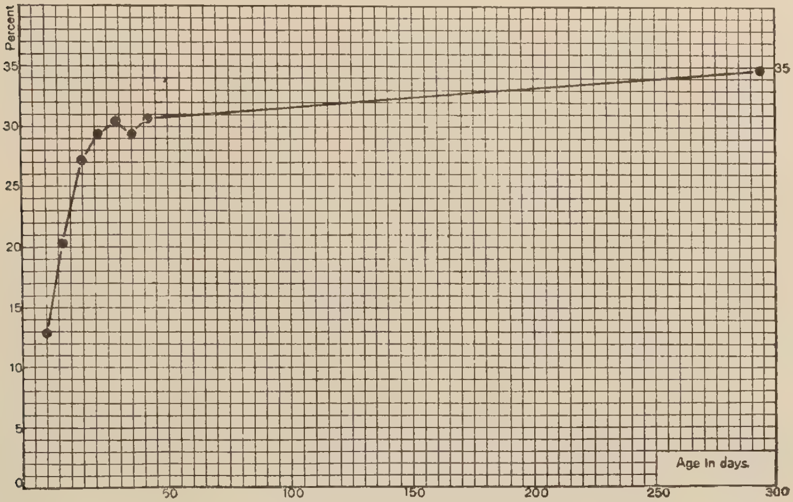

Chart 56. Showing the growth of the dry substance (solids) as a percentage of body weight, in the albino rat during the first third of its life span. Data in table 166. To be compared with the corresponding graph in chart 50.

Using the data for fat given in table 166, Moulton ('23) has computed the percentages of water and of ash in Hatai's series—on a fat free basis—including also observations by Zuntz ('18) at birth, and Inaba ('11) at maturity. These values are of course increased under such conditions.

In a study of the effect of antenatal feeding on the weight and composition of the young, Korenchevsky and Carr ('23a) used the following diets:

D 1, consisting of milk, cabbage, oats, bran and white bread.

N 2, containing a liberal amount of fat-soluble factor in the form of butter and cod-liver oil, 0.52 per cent Ca and 0.5 per cent P (in fresh diet).

-A, a diet similar to N 2, but deficient in fat-soluble factor, the only source of fat being cotton seed oil, and containing only 0.25 per cent Ca in the fresh diet.

TABLE 167

*Average weights of mothers*

| NUMBER OF MOTHERS | DIETS OF MOTHERS | | WEIGHT OF MOTHERS | |
|---|---|---|---|---|
| | Before conception | During pregnancy | Four weeks before littering | After littering |
| | | | *grams* | *grams* |
| 14 | N 2 | N 2 | 179 | 212 |
| 16 | D 1 | −A or D 1 | 149 | 171 |

TABLE 168

*Average weight and composition of the young at birth*

| DIETS OF MOTHER | | AVERAGE WEIGHT* | | IN YOUNG | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $H_2O$ per cent | Ca per cent | | P per cent | | N per cent | |
| Before conception | During pregnancy | Of one fresh young | Of one dry young | | Fresh | Dry | Fresh | Dry | Fresh | Dry |
| | | *grams* | *grams* | | | | | | | |
| N 2 | N 2 | 4.71 | 0.64 | 86.31 | 0.31 | 2.26 | 0.30 | 2.12 | 1.60 | 11.70 |
| N 2 | N 2 | 4.90 | 0.68 | 86.32 | 0.30 | 2.19 | 0.32 | 2.34 | 1.65 | 12.06 |
| D 1 | −1 | 4.64 | 0.66 | 85.97 | 0.35 | 2.49 | 0.35 | 2.49 | 1.73 | 12.33 |
| D 1 | D 1 or −A | 4.70 | 0.66 | 86.24 | 0.31 | 2.25 | 0.30 | 2.18 | 1.65 | 11.99 |

* The figures in these two columns represent the weights of the young after removal of stomach and intestines.

Their results appear in tables 167 and 168.

In the course of a study on the influence of diet on the teeth and bones, Toverud ('23) has determined the inorganic constituent in newborn rats from normal mothers,—table 169.

In connection with a study of the phosphorus compounds in the Albino after ovariotomy Heymann ('04) has recorded the $P_2O_5$ distribution in the normal rat (see Keith and Forbes, '14). His data for the normal appear in table 170.

(*a*) *Organs and tissues.* Hatai ('17) has determined the total nitrogen as well as the non-protein nitrogen in several organs of the adult albino—table 171.

TABLE 169

*Inorganic constituents in new born rats from normal mothers. Average of two rats (Toverud '23)*

| ASH ON BODY WEIGHT | Ca ON BODY WEIGHT | Ca ON ASH | P ON BODY WEIGHT | P ON ASH | Mg ON BODY WEIGHT | Mg ON ASH |
|---|---|---|---|---|---|---|
| *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| 1.576 | 0.2705 | 17.16 | 0.267 | 16.88 | 0.0218 | 1.395 |

TABLE 170

*Giving the distribution of phosphorus in the albino rat (Heymann, '04)*

| | TISSUES, PER CENT OF DRY SUBSTANCE | | | | BONES, PER CENT TOTAL $P_2O_5$ | | BONES AND TISSUES TOTAL $P_2O_5$ |
|---|---|---|---|---|---|---|---|
| | Lecithin $P_2O_5$ | Nuclein $P_2O_5$ | Phosphate $P_2O_5$ | Total $P_2O_5$ | Fresh substance | Dry substance | Per cent of total body weight |
| Normal.... | 0.4760 | 0.0559 | 2.4479 | 2.9798 | 21.2690 | 24.0556 | 1.9819 |
| Normal.... | | | | | 18.1665 | 22.8105 | 1.2980 |
| Normal.... | 0.3242 | 0.0649 | 1.6490 | 1.9830* | 17.0315 | 19.2083 | ? |
| Normal.... | 0.3608 | 0.0979 | 1.5430 | 2.0018 | 17.5724 | 19.9277 | 1.3795 |

* Apparently erroneous since the sum of the figures for nuclein, lecithin and phosphate phosphorus is 2.0381 per cent.

TABLE 171

*Showing the total nitrogen as well as non-protein nitrogen in several organs of the adult albino rat*

| | TOTAL NITROGEN IN FRESH TISSUE | NON-PROTEIN NITROGEN PER 100 GRAMS FRESH TISSUE | NON-PROTEIN NITROGEN TO TOTAL NITROGEN | AGE |
|---|---|---|---|---|
| | *per cent* | *mgm.* | *per cent* | *days* |
| Brain...................... | 1.953 | 159 | 8.168 | 143 |
| Testes...................... | 1.729 | 170 | 9.806 | 143 |
| Liver...................... | 3.435 | 182 | 5.332 | 143 |
| Kidneys...................... | 3.243 | 229 | 7.572 | 143 |
| Blood...................... | 3.093 | 35 | 1.134 | 241 |

Calcium in the blood has been determined on three normal adult rats, Toverud ('23), table 172.

*Composition of milk.* By carefully collecting the stomach contents immediately after ingestion from albino rats 1-14 days old, Hatai ('17) has sought to determine the composition of the milk in this animal. The average results are given in table 173.

2. *Osseous system.* The gross chemical composition of the humerus and femur in the male and female albinos, at two ages has been determined by Hammett ('23). Tables 174 and 175 show the values with the statistical constants.

TABLE 172

*Calcium in blood serum. Three male mature rats on a mixed diet*

| RAT | CALCIUM IN 100 CC. OF SERUM |
|---|---|
| | *mgm.* |
| C | 11.1 |
| D | 11.1 |
| E | 12.0 |

TABLE 173

*Composition of rat milk (Hatai '17)*

| | COMPOSITION | | | |
|---|---|---|---|---|
| | Water | Solids | As per cent of solids | As per cent of moist weight |
| | *per cent* | *per cent* | | |
| | 54.3 | 45.7 | | |
| Solids comprise: | | | | |
| Residue | | | 22.1 | 10.1 |
| Fat | | | 69.1 | 31.6 |
| Organic Extracts | | | 5.3 | 2.4 |
| Salts : Soluble | | | 2.0 | 0.9 |
| Salts : Fixed | | | 1.5 | 0.7 |
| Total | | | 100.0 | 45.7 |
| Total ash | | | 3.5 | 1.6 |
| Ash in lipoid-free solids | | | 11.1 | |
| Ash in residue | | | 6.2 | |

The differences according to age are evident. The differences according to sex are in part at least to be referred to the more rapid development of the female.

In a study on the salt content of the bones (Hammett, '23) found the relations in the normal humerus and femur to be as in table 176.

With regard to the data in this table 176 Hammett ('23 g) makes the following comment:

> At 100 days of age the percentage value of calcium, magnesium, and phosphorus of the humerus ash is practically the same as that of the femur, notwithstanding the markedly heavier ash and greater absolute amount of the three constituents in the latter. There is, however, a slight but valid superiority in the percentage of phosphorus exhibited by the femur. Since this is present in both sexes, and is shown in all the groups, it is undoubtedly significant.

TABLE 174

*The statistical data of the gross chemical composition of the humerus and femur of the normal male rats in terms of fresh weight at two ages*

| | FRESH WEIGHT | DRY WEIGHT | $H_2O$ | | ORGANIC MATTER | | ASH | |
|---|---|---|---|---|---|---|---|---|
| | *grams* | *grams* | *grams* | *per cent* | *grams* | *per cent* | *grams* | *per cent* |
| *100 days of age, 11 rats* | | | | | | | | |
| Humerus | | | | | | | | |
| M........ | 0.1847 | 0.1100 | 0.0747 | 40.70 | 0.0397 | 21.49 | 0.0703 | 37.81 |
| S. D...... | 0.0272 | 0.0132 | 0.0079 | 2.06 | 0.0059 | 1.18 | 0.0138 | 1.93 |
| P. E. M.. | 0.0055 | 0.0027 | 0.0016 | 0.42 | 0.0012 | 0.24 | 0.0028 | 0.39 |
| C. V...... | 14.73 | 12.00 | 10.58 | 5.05 | 14.86 | 5.49 | 19.63 | 5.10 |
| Femur | | | | | | | | |
| M........ | 0.4050 | 0.2342 | 0.1709 | 42.68 | 0.0884 | 21.74 | 0.1457 | 35.58 |
| S. D...... | 0.0644 | 0.0522 | 0.0147 | 3.41 | 0.0165 | 0.69 | 0.0358 | 2.87 |
| P. E. M.. | 0.0131 | 0.0106 | 0.0030 | 0.69 | 0.0034 | 0.14 | 0.0073 | 0.58 |
| C. V...... | 15.90 | 22.29 | 8.60 | 8.00 | 18.67 | 3.17 | 24.57 | 8.05 |
| *150 days of age, 11 rats* | | | | | | | | |
| Humerus | | | | | | | | |
| M........ | 0.2398 | 0.1548 | 0.0849 | 35.68 | 0.0525 | 21.47 | 0.1031 | 42.85 |
| S. D...... | 0.0257 | 0.0211 | 0.0086 | 3.13 | 0.0072 | 1.33 | 0.0153 | 2.41 |
| P. E. M.. | 0.0052 | 0.0043 | 0.0017 | 0.64 | 0.0015 | 0.27 | 0.0031 | 0.49 |
| C. V...... | 10.72 | 13.63 | 10.13 | 8.78 | 13.71 | 6.19 | 14.84 | 5.62 |
| Femur | | | | | | | | |
| M........ | 0.5300 | 0.3361 | 0.1939 | 36.72 | 0.1222 | 23.06 | 0.2140 | 40.21 |
| S. D...... | 0.0612 | 0.0469 | 0.0192 | 2.50 | 0.0143 | 0.95 | 0.0342 | 2.80 |
| P. E. M.. | 0.0124 | 0.0095 | 0.0039 | 0.51 | 0.0029 | 0.19 | 0.0069 | 0.57 |
| C. V...... | 11.55 | 13.95 | 9.90 | 6.81 | 11.70 | 4.12 | 15.98 | 6.96 |

At 100 days of age no significant sex difference is exhibited in the percentage of magnesium and phosphorus. The percentage of calcium in the ash of both bones, however, is greater in the females than in the males. This sex difference is an accompaniment of the more advanced state of ossification of the bones in the females as shown by their higher percentage of ash. (Hammett '24 a)

TABLE 175

*The statistical data of the gross chemical composition of the humerus and femur of normal female rats at two ages*

| | FRESH WEIGHT | DRY WEIGHT | $H_2O$ | | ORGANIC MATTER | | ASH | |
|---|---|---|---|---|---|---|---|---|
| *100 days of age, 10 rats* | | | | | | | | |
| Humerus | | | | | | | | |
| | *grams* | *grams* | *grams* | *per cent* | *grams* | *per cent* | *grams* | *per cent* |
| M........ | 0.1732 | 0.1110 | 0.0623 | 36.07 | 0.0380 | 21.92 | 0.0729 | 42.01 |
| S. D...... | 0.0144 | 0.0121 | 0.0052 | 2.80 | 0.0035 | 0.46 | 0.0087 | 2.46 |
| P. E. M.. | 0.0031 | 0.0026 | 0.0011 | 0.60 | 0.0007 | 0.10 | 0.0019 | 0.53 |
| C. V...... | 8.31 | 10.90 | 8.35 | 7.77 | 9.21 | 2.11 | 11.93 | 5.87 |
| Femur | | | | | | | | |
| M........ | 0.3818 | 0.2388 | 0.1431 | 37.65 | 0.0849 | 22.23 | 0.1539 | 40.12 |
| S. D...... | 0.0422 | 0.0337 | 0.0152 | 3.32 | 0.0099 | 0.79 | 0.0241 | 2.86 |
| P. E. M.. | 0.0090 | 0.0072 | 0.0032 | 0.80 | 0.0021 | 0.17 | 0.0051 | 0.61 |
| C. V...... | 11.05 | 14.11 | 10.62 | 8.83 | 11.66 | 3.57 | 15.66 | 7.13 |
| *150 days of age, 11 rats* | | | | | | | | |
| Humerus | | | | | | | | |
| M........ | 0.2090 | 0.1433 | 0.0657 | 31.58 | 0.0472 | 22.59 | 0.0962 | 45.83 |
| S. D...... | 0.0308 | 0.0231 | 0.0085 | 2.02 | 0.0068 | 0.69 | 0.0166 | 2.17 |
| P. E. M.. | 0.0063 | 0.0047 | 0.0017 | 0.41 | 0.0014 | 0.14 | 0.0034 | 0.44 |
| C. V...... | 14.74 | 16.12 | 12.94 | 6.40 | 14.41 | 3.04 | 17.26 | 4.74 |
| Femur | | | | | | | | |
| M........ | 0.4584 | 0.3064 | 0.1521 | 33.44 | 0.1058 | 23.13 | 0.2006 | 43.43 |
| S. D...... | 0.0752 | 0.0576 | 0.0193 | 2.29 | 0.0164 | 0.88 | 0.0418 | 2.63 |
| P. E. M.. | 0.0153 | 0.0117 | 0.0039 | 0.47 | 0.0033 | 0.18 | 0.0085 | 0.54 |
| C. V...... | 16.40 | 18.80 | 12.69 | 6.85 | 15.50 | 3.82 | 20.84 | 6.06 |

At 150 days of age the identity of the humerus and femur ash in calcium and magnesium percentage, the superiority of the femur in percentage of phosphorus, and the higher percentage of calcium in the bones of the females are shown, as at 100 days of age, and are similarly interpretable.

TABLE 176

*Statistical data of the calcium, magnesium, and phosphorus content of the ash of the humerus and femur at two ages*

| | HUMERUS | | | | | | | FEMUR | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ash | Calcium | | Magnesium | | Phosphorus | | Ash | Calcium | | Magnesium | | Phosphorus | |
| *Male rats*<br>100 days old, 11 rats | | | | | | | | | | | | | | |
| | *gm.* | *mg.* | *per cent* | *mg.* | *per cent* | *mg.* | *per cent* | *gm.* | *mg.* | *per cent* | *mg.* | *per cent* | *mg.* | *per cent* |
| M. | 0.0703 | 26.30 | 37.40 | 0.600 | 0.85 | 12.91 | 18.34 | 0.1457 | 54.45 | 37.32 | 1.258 | 0.86 | 27.03 | 18.54 |
| S. D. | 0.0138 | 5.19 | 0.18 | 0.133 | 0.05 | 2.65 | 0.33 | 0.0358 | 13.61 | 0.31 | 0.381 | 0.06 | 6.69 | 0.27 |
| P. E. M. | 0.0028 | 1.06 | 0.04 | 0.027 | 0.01 | 0.54 | 0.07 | 0.0073 | 2.77 | 0.06 | 0.077 | 0.01 | 1.36 | 0.05 |
| C. V. | 19.63 | 19.74 | 0.47 | 22.20 | 6.13 | 20.53 | 1.79 | 24.57 | 25.00 | 0.83 | 30.28 | 7.49 | 24.73 | 1.43 |
| 150 days old, 11 rats | | | | | | | | | | | | | | |
| M. | 0.1031 | 38.73 | 37.52 | 0.899 | 0.86 | 18.87 | 18.25 | 0.2140 | 80.38 | 37.53 | 1.754 | 0.82 | 39.92 | 18.32 |
| S. D. | 0.0153 | 5.88 | 0.70 | 0.199 | 0.09 | 3.09 | 0.58 | 0.0342 | 13.22 | 0.57 | 0.279 | 0.08 | 6.58 | 0.58 |
| P. E. M. | 0.0031 | 1.20 | 0.14 | 0.041 | 0.02 | 0.63 | 0.12 | 0.0069 | 2.69 | 0.12 | 0.057 | 0.02 | 1.34 | 0.12 |
| C. V. | 14.84 | 15.18 | 1.85 | 22.15 | 10.58 | 16.39 | 3.20 | 15.98 | 16.45 | 1.52 | 15.89 | 9.73 | 16.48 | 3.13 |
| *Female rats*<br>100 days old, 10 rats | | | | | | | | | | | | | | |
| M. | 0.0729 | 27.57 | 37.83 | 0.605 | 0.84 | 13.47 | 18.47 | 0.1539 | 57.99 | 37.66 | 1.291 | 0.84 | 28.56 | 18.57 |
| S. D. | 0.0087 | 4.20 | 0.31 | 0.051 | 0.06 | 1.58 | 0.15 | 0.0241 | 9.37 | 0.37 | 0.178 | 0.05 | 4.44 | 0.20 |
| P. E. M. | 0.0019 | 0.90 | 0.07 | 0.011 | 0.01 | 0.34 | 0.03 | 0.0051 | 2.00 | 0.08 | 0.038 | 0.01 | 0.95 | 0.04 |
| C. V. | 11.93 | 15.25 | 0.83 | 8.48 | 6.60 | 11.75 | 0.81 | 15.66 | 16.16 | 0.98 | 13.82 | 5.62 | 15.53 | 1.07 |
| 150 days old, 11 rats | | | | | | | | | | | | | | |
| M. | 0.0962 | 36.36 | 37.80 | 0.826 | 0.85 | 17.60 | 18.29 | 0.2006 | 75.85 | 37.76 | 1.703 | 0.85 | 37.01 | 18.45 |
| S. D. | 0.0166 | 5.84 | 0.60 | 0.245 | 0.16 | 3.22 | 0.78 | 0.0418 | 15.92 | 0.48 | 0.429 | 0.10 | 8.36 | 0.50 |
| P. E. M. | 0.0034 | 1.19 | 0.12 | 0.050 | 0.03 | 0.66 | 0.16 | 0.0085 | 3.24 | 0.10 | 0.087 | 0.02 | 1.70 | 0.10 |
| C. V. | 17.26 | 16.06 | 1.59 | 29.69 | 18.94 | 18.31 | 4.27 | 20.84 | 20.99 | 1.26 | 25.20 | 12.25 | 22.59 | 4.92 |

The sex differences in absolute amounts of ash, and of calcium, magnesium, and phosphorus of the ash at both ages are too small to be individually valid, yet the consistency of the direction of deviation shows that the bones of the females at 100 days of age have absolutely greater amounts of ash, calcium, magnesium, and phosphorus than do those of the males, and that at 150 days the conditions are reversed. The correctness of this supposition is supported by the fact that the rate of growth of the humerus and femur in the male rats during the period of observation is greater than that of the females in weight, length, water, organic matter, ash, calcium, magnesium, and phosphorus.

There is apparently a slight difference between the results given in table 176 and those obtained when the diaphysis alone is analysed (Toverud, '23) table 177 (1). This latter table contains also the corresponding data (2) for the molar teeth and (3) for the incisors.

TABLE 177

*Inorganic constituents of the femur and teeth (Toverud, '23)*

(1) Analysis of bones (Diaphysis of femur).
Average from three mature rats—two males, one female—fed on normal mixed diet.
(2) Analysis of molar teeth.
(3) Analysis of incisor teeth.

| ASH OF DRY BONE | Ca OF DRY BONE | Ca OF ASH | P OF DRY BONE | P OF ASH | Mg OF DRY BONE | Mg OF ASH |
|---|---|---|---|---|---|---|
| *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| (1) 67.5 | 26.0 | 39.0 | 11.9 | 17.8 | 0.51 | 0.75 |
| Dry teeth | Dry teeth | | Dry teeth | | Dry teeth | |
| (2) 78.4 | 30.7 | 39.6 | 14.5 | 18.6 | 0.46 | 0.61 |
| (3) 78.5 | 28.9 | 36.8 | 14.9 | 19.1 | 1.67 | 2.12 |

On a calcium deficient diet a decrease in total ash and calcium oxide occurs in all the tests made, Toverud ('23). The occurrence of this change in the permanent molar teeth is especially worthy of note.

3. *In the nervous system.* With the purpose of following the changes in the chemical constituents of the brain with advancing age, Koch, W. and M. L. ('13 a) have made a series of observations and to these have been added also observations on one spinal cord at 120 days. The results are given in tables 178 and 179.

In chart 57 are given the graphs for the absolute weights of the more important chemical constituents of the brain plotted on age (see table 179).

TABLE 178

*Chemical composition of the brain of the albino rat at different ages. Duplicate analyses*

| | | | | | | | | | | | | *Cord of the albino rat.* (Inserted for comparison.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age in days | 1 | | 10 | | 20 | | 40 | | 120 | | 210 | 120 |
| Body weight in grams | 5.5 | | 12 | | 20 | | 43 | | 112.3 | | 182 | 112.3 |
| Moist weight of one brain in grams | 0.250 | 0.250 | 0.860 | 0.860 | 1.228 | 1.329 | 1.397 | 1.368 | 1.659 | 1.551 | 1.667 | 0.365 |
| Solids in per cent | 10.420 | 10.420 | 14.700 | 12.500 | 17.500 | 17.500 | 20.100 | 20.580 | 21.600 | 21.700 | 21.900 | 27.100 |
| Dry weight of one brain in grams | 0.026 | 0.026 | 0.127 | 0.107 | 0.215 | 0.233 | 0.281 | 0.282 | 0.358 | 0.336 | 0.365 | 0.099 |
| Number of brains in sample | 100 | 100 | 40 | 40 | 48 | 59 | 37 | 34 | 30 | 31 | 31 | 90 |
| *Constituents in per cent of solids* | | | | | | | | | | | | |
| Proteins | 58.20 | 58.30 | 56.40 | 56.50 | 53.90 | 52.70 | 48.70 | 48.10 | 47.20 | 48.00 | 48.50 | 32.80 |
| Phosphatides | 14.80 | 15.60 | 10.60 (?) | 12.30 | 21.10 | 21.70 | 20.00 | 23.20 | 21.90 | 21 30 | 22.00 | 25.30 |
| Cerebrosides | * | * | * | * | 3.10 | 2.90 | 6.30 | 5.50 | 6.60 (?) | 8.40 | 8.40‡ | 12.50 |
| Sulphatides | 1.50 | 1.40 | 0.73 (?) | 2.60 | 2.40 | 2.60 | 2.70 | 2.40 | 3.50 | 3.60 | 4.50 | 7.00 |
| Organic extractives } | 16.50 | 19.30 | 19.30 | 15.10 | 13.80 | 15.30 | 13.80 | 15.90 | 9.70 | 9.80 | 9.80‡ | 7.60 |
| Inorganic constituents } | | | | | | | | | | | | |
| Cholesterol (undetermined)† | 9.00 | 5.40 | 13.00 | 13.50 | 5.70 | 4.80 | 8.00 | 4.90 | 11.10 | 8.90 | 6.80 | 14.80 |
| Total sulphur | 0.96 | 1.04 | 0.72 | 0.83 | 0.69 | 0.70 | 0.58 | 0.52 | 0.55 | 0.57 | 0.58 | 0.45 |
| Total phosphorus | 1.82 | 1.92 | 1.28 | 1.48 | 1.66 | 1.67 | 1.55 | 1.50 | 1.40 | 1.44 | 1.39 | 1.44 |
| *Distribution of sulphur in per cent of total S* | | | | | | | | | | | | |
| Protein S | 31.1 | 30.0 | 48.6 | 44.2 | 57.5 | 55.3 | 65.1 | 62.4 | 61.2 | 62.4 | 63.8 | 53.6 |
| Lipoid S | 3.2 | 2.8 | 2.2 | 6.1 | 6.7 | 7.5 | 9.2 | 10.1 | 12.8 | 12.5 | 15.6 | 30.9 |
| Neutral S | 49.1 | 47.3 | 45.1 | 45.4 | 29.7 | 27.5 | 17.0 | 19.3 | 19.2 | 18.3 | 14.5 | 10.3 |
| Inorganic S | 16.6 | 19.9 | 4.1 | 4.3 | 6.1 | 9.7 | 8.7 | 8.2 | 6.8 | 6.8 | 6.1 | 5.1 |
| *Distribution of phosphorus in per cent of total P* | | | | | | | | | | | | |
| Protein P | 13.3 | | 13.0 | 13.9 | 6.0 | 5.8 | 9.9 | 7.5 | 7.4 | 7.3 | 6.8 | 5.6 |
| Lipoid P | 33.2 | 33.0 | 33.8 | 36.1 | 52.2 | 53.5 | 56.1 | 58.5 | 65.8 | 62.3 | 67.6 | 77.4 |
| Water Sol. P | 53.5 | 53.6 | 53.2 | 50.0 | 41.8 | 40.7 | 34.0 | 34.0 | 26.8 | 30.4 | 25.6 | 17.0 |

* Cerebrosides not determined in brains at birth and 10 days. Probably none present at this age.

† By difference. ? Indicates doubtful result. ‡ Taken from preceding entry.

TABLE 179

*Absolute weights, in milligrams, of the constituents of a single brain of the albino rat at different ages (prepared from Table 178)*

| | AGE IN DAYS | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 10 | 20 | 40 | 120 | 210 |
| Moist weight of one brain in grams | 0.250 | 0.860 | 1.280 | 1.380 | 1.600 | 1.670 |
| Solids in per cent | 10.420 | 12.500 | 17.500 | 20.340 | 21.650 | 21.900 |
| Dry weight of one brain in grams | 0.026 | 0.107 | 0.224 | 0.281 | 0.347 | 0.365 |
| *Absolute weights in milligrams* | | | | | | |
| Proteins (1)‡ | 15.14* | 60.45† | 119.40* | 136.00* | 165.20* | 177.00† |
| Phosphatides (2) | 3.95 | 13.16 | 47.90 | 61.30 | 74.95 | 80.30 |
| Cerebrosides (3) | | | 6.70 | 16.60 | 29.15 | 30.66 |
| Sulphatides (4) | 0.38 | 2.78 | 5.60 | 7.20 | 12.30 | 16.40 |
| Organic extractives<br>Inorganic constituents | 4.65 | 16.16 | 32.60 | 41.70 | 33.80 | 35.80 |
| Cholesterol undetermined (5) | 1.87 | (14.45) | 11.70 | 18.20 | 31.60 | 24.80 |
| Total sulphur | 0.26 | 0.90 | 1.57 | 1.54 | 1.94 | 2.12 |
| Total phosphorus | 0.48 | 1.60 | 3.72 | 4.30 | 4.93 | 5.07 |
| *In absolute weight in milligrams of sulphur* | | | | | | |
| Protein S (1S)§ | 0.079 | 0.398 | 0.885 | 0.982 | 1.199 | 1.352 |
| Lipoid S (4) | 0.008 | 0.054 | 0.111 | 0.149 | 0.246 | 0.330 |
| Neutral S (6) | 0.125 | 0.409 | 0.449 | 0.279 | 0.363 | 0.307 |
| Inorganic S (7) | 0.047 | 0.039 | 0.122 | 0.130 | 0.132 | 0.129 |
| *In absolute weight in milligrams of phosphorus* | | | | | | |
| Protein P (1P) | 0.064 | 0.215* | 0.220 | 0.374 | 0.360 | 0.345 |
| Lipoid P (2) | 0.161 | 0.558 | 1.964 | 2.464 | 3.160 | 3.427 |
| Water sol. P (8) | 0.260 | 0.826 | 1.532 | 1.462 | 1.410 | 1.298 |

* Record from average: duplicate analyses.

† Record from one analysis.

‡ Figures in parentheses in this section refer to Chart III. See original.

§ Figures in parentheses in this and the following sections refer to Chart IV. See original.

*Nitrogen Content.* Using trichloracetic acid for extracting water soluble organic substances from nerve tissue, Hatai ('17 a) has determined the content of total nitrogen and of non-protein nitrogen in the entire brain of the Albino at different ages. The data are arranged in table 180.

In chart 58 a graph is presented for the non-protein nitrogen per gram of dried brain at different ages.

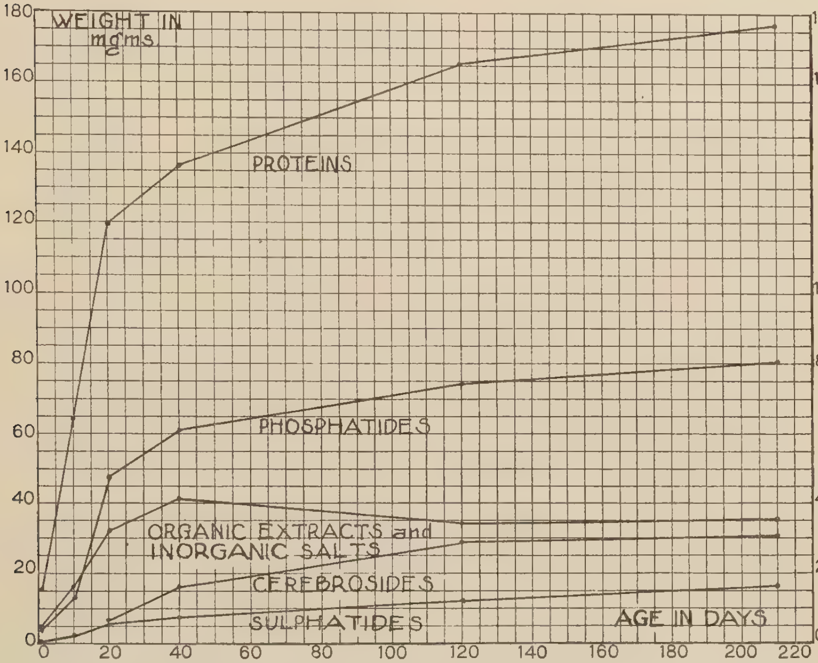

Chart 57. Giving in milligrams the absolute weight of the more important chemical constituents of the brain. Plotted on age. Table 179.

Hatai ('17 a) followed at two ages the distribution of nitrogen in the three divisions of the brain and in the spinal cord. His results are given in tables 181 and 182.

When the lipoids have been removed (Hatai, '17 a) it appears that in the several divisions of the nervous system the relation between the protein nitrogen and the nitrogen content of the extractives is nearly constant as shown in table 183.

TABLE 180

*Showing the content of total nitrogen as well as non-protein nitrogen in the entire brain of the albino rat at different ages*

| (a) BODY WEIGHT | (b) BRAIN WEIGHT | (c) WATER IN BRAIN | (d) SOLIDS | (e) TOTAL NITROGEN IN ENTIRE BRAIN | (f) NON-PROTEIN NITROGEN IN ENTIRE BRAIN | (g) TOTAL NITROGEN TO SOLIDS | (h) NON-PROTEIN NITROGEN TO TOTAL NITROGEN | (i) NON-PROTEIN NITROGEN PER GRAM OF SOLIDS | (j) MEAN AGE | (k) NUMBER OF RATS USED |
|---|---|---|---|---|---|---|---|---|---|---|
| *grams* | *grams* | *per cent* | *grams* | *mgm.* | *mgm.* | *per cent* | *per cent* | *mgm.* | *days* | |
| 4.8 | 0.231 | 88.30 | 0.027 | 3.07 | 0.38 | 11.40 | 12.33 | 14.1 | 1 | 45 |
| 7.1 | 0.459 | 88.75 | 0.052 | 5.73 | 0.71 | 11.08 | 12.38 | 13.7 | 5 | 32 |
| 9.5 | 0.598 | 88.13 | 0.071 | 7.70 | 0.91 | 10.86 | 11.81 | 12.8 | 7 | 17 |
| 17.9 | 1.175 | 84.90 | 0.177 | 18.28 | 1.63 | 10.30 | 8.89 | 9.2 | 15 | 12 |
| 26.7 | 1.284 | 80.86 | 0.246 | 23.70 | 2.11 | 9.65 | 8.91 | 8.6 | 24 | 6 |
| 34.8 | 1.379 | 80.26 | 0.272 | 26.21 | 2.22 | 9.63 | 8.48 | 8.2 | 35 | 6 |
| 66.6 | 1.508 | 79.58 | 0.308 | 28.00 | 2.42 | 9.09 | 8.64 | 7.9 | 54 | 6 |
| 156.6 | 1.762 | 78.89 | 0.372 | 33.72 | 2.63 | 9.07 | 7.81 | 7.1 | 116 | 6 |
| 161.4 | 1.803 | 78.43 | 0.389 | 34.13 | 2.59 | 8.78 | 7.58 | 6.7 | 274 | 6 |
| 185.5 | 1.858 | 78.00 | 0.409 | 35.94 | 2.89 | 8.79 | 8.04 | 7.1 | 382 | 6 |

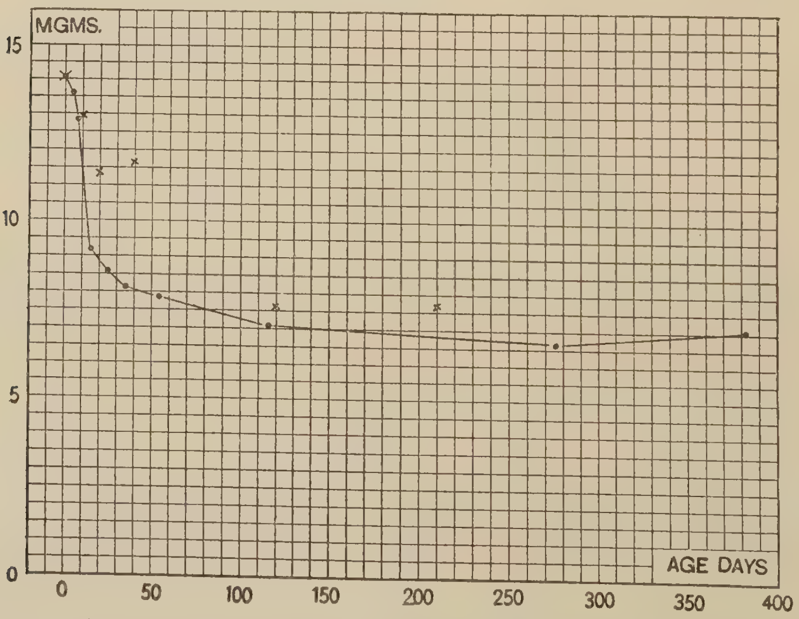

Chart 58. Showing the number of milligrams of non-protein nitrogen per gram of the dried brain at different ages. The chart shows also the proportional value of organic extractives together with inorganic salts in the brain of the albino rat, as determined by W. Koch and M. L. Koch ('13). ·—· Non-protein nitrogen, × organic extractives and inorganic salts.

### TABLE 181

*Showing the nitrogen content in the non-proteins, the amino acids, the urea and the ammonia in four different parts of the central nervous system of the albino rat*

| ALBINO RAT | MILLIGRAMS OF NITROGEN PER GRAM OF TOTAL SOLIDS | | | | | |
|---|---|---|---|---|---|---|
| | 106 days old | | | | One year old | |
| | Non-proteins | Amino acids | Urea | Ammonia | Non-proteins | Amino acids |
| Cerebellum | 8.61 | 3.62 | 0.98 | 0.93 | 7.08 | 2.74 |
| Cerebrum | 8.53 | 3.67 | 0.57 | 0.77 | 6.98 | 3.06 |
| Stem | 6.04 | 2.91 | 0.65 | 0.58 | 4.86 | 1.74 |
| Spinal cord | 5.26 | 2.38 | 0.47 | 0.53 | 4.08 | 1.48 |

### TABLE 182

*Showing the water content, the total nitrogen in solids, lipoids in solids and also nitrogen content in lipoids in different parts of the central nervous system*

| ALBINO RAT | 106 DAYS OLD | | | | ONE YEAR OLD | |
|---|---|---|---|---|---|---|
| | Water | Nitrogen to total solids | Lipoids to total solids | Lipoid nitrogen to total nitrogen | Water | Nitrogen to total solids |
| | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| Cerebellum | 79.36 | 10.10 | 42.13 | 17.63 | 78.41 | 9.18 |
| Cerebrum | 79.38 | 9.51 | 42.36 | 17.22 | 78.38 | 9.09 |
| Stem | 75.16 | 7.75 | 55.03 | 19.90 | 73.14 | 7.06 |
| Spinal cord | 72.23 | 6.38 | 62.03 | 20.11 | 69.00 | 5.90 |

### TABLE 183

*Showing percentage of nitrogen in the various nitrogenous organic extractives in relation to the lipoid free solids (protein) in different parts of the central nervous system, together with the percentage of water*

| ALBINO RAT 106 DAYS OLD | PERCENTAGE OF NITROGEN TO PROTEIN NITROGEN | | | | PERCENTAGE OF WATER TO LIPOID-FREE DIVISION |
|---|---|---|---|---|---|
| | Non-proteins | Amino acids | Urea | Ammonia | |
| Cerebellum | 10.34 | 4.35 | 1.17 | 1.11 | 86.92 |
| Cerebrum | 10.49 | 4.51 | 0.70 | 0.94 | 86.99 |
| Stem | 9.72 | 4.68 | 1.05 | 0.94 | 87.06 |
| Spinal cord | 10.33 | 4.67 | 0.93 | 1.04 | 87.26 |
| Averages | 10.22 | 4.55 | 0.96 | 1.01 | 87.06 |

The value for the percentage of water (table 183) is similar in the several divisions and nearly as high as that in the brain and cord at birth. Thus the water-solids relation is not significantly altered in older rats, if the lipoids are excluded from consideration. These results further confirm the conclusion of Donaldson ('16) that the reduction of the percentage of water in the nervous system with advancing age is due mainly to the accumulation of myelin in it.

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# CHAPTER 10

# PATHOLOGY

1. General. 2. Rat diseases. 3. Toxicology. 4. References to Literature.

1. *General.* In the various studies on the pathology of the rat there are, of course, some data, which might be tabulated or charted. It has been thought best, however, to adhere to our general plan of treating in detail the data for the normal animal only and the presentation in this chapter is therefore mainly to a series of references, including those on the Norway as well as the Albino, classified according to the subheads there given.

Touching the value of the rat for pathological studies the following citations are given.

> The value of the rat as an experimental animal was impressed upon one of us five years ago when studying, in association with Dr. F. B. Mallory, the lesions produced by a typhoid-like organism, Danysz virus, or B. typhi murium. The likeness between these histological changes and those occurring in typhoid fever in man were striking (Mallory and Ordway, '09).
>
> The intimate relation of the rat to man, as an intermediary host in certain diseases, the similar omnivorous character of its diet, the natural occurrence and experimental production of morbid conditions similar to those occurring in man make the rat not only an important animal to study in its relation to the public health, as has been done so ably by the United States Public Health and Marine Hospital service, but in its relation to general and special problems of disease, from the physiological and the chemical, as well as from the anatomical and histological point of view (Ordway and Morris, '13).

2. *Rat diseases.* The commonest ailment is a lung infection, often designated as "rat pneumonia." Studies on this have been made by Hektoen '16; Tunnicliff '16; Jones '22 and a number of others.

This disease occurs in the wild Norway as well as in the Albino. It seems less frequent in Albinos allowed to exercise, but is very commonly present in all rats over two years of age. In some colonies middle ear infection frequently occurs and produces disequilibration and circular movements. Such rats when held up by the tail execute a spinning movement. This is diagnostic. In the Institute colony at present middle ear disease is found in about one per cent of the animals.

These two ailments are the most common ones observed. From time to time animals come to autopsy with organs missing on one side and other defects, both congenital and acquired, but a detailed study of these has yet to be made.

3. *Toxicology.* The studies of Hammett and Nowrey ('22 b) show that with advancing age there is a progressive diminution in the resistance of the albino rat to death from arsenic poisoning. A dose of 11 mgm. per kilo or over of arsenic trioxide is fatal to young rats of 60 to 90 days of age. By the time the animals have reached the age of 120 to 150 days a dose of 9 mgm. is fatal. When they are 210 to 240 days old, 8 mgm. is the amount which produces death within 24 hours in the average animal.

These differences in susceptibility with age are attributable in large part to differences in metabolic rates.

It is to be noted also that the proportional weight of the abdominal and thoracic viscera *decreases* in nearly the same proportion that the fatal dose decreases.

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# PART II

## NORWAY RAT

WILD—CAGED—DOMESTICATED

# CHAPTER 11

# LIFE HISTORY AND DISTINGUISHING CHARACTERS NORWAY RAT

1. Introduction. 2. Life history. 3. Comparison of Norway with Albino. 4. Similarities of Norways and Albinos in western Europe and United States.

1. *Introduction.* To obtain more complete information concerning the rat it is important to note differences which may appear between the domesticated Albino and the wild Norway. Since the wild Norway represents the parent stock it might seem proper to use that form as the standard and to record the deviations of the Albino from it. As a matter of fact however our information with regard to the Albino is so much the more complete that the best results will follow from using it as the standard, despite that fact that zoölogically it is but a variety of the Norway.

The wild Norway rat has special value as a form with which the effect of domestication can be systematically studied. It must always be remembered in this connection however that only a limited series of observations can be made on the strictly wild Norway. Many of the observations here to be presented are on the caged and partially domesticated strains, and since this treatment tends to modify several characters in the wild Norway, care will be taken to state clearly just which strain of Norway was used for observation.

2. *Life history.* As regards behavior, the Norway rat is very responsive to sounds, gnaws its cage, burrows when opportunity offers, is hard to handle and appears fierce because usually in a state of terror, yet after some days in a cage, mature rats occasionally become quite docile. On occasion it swims and dives.

The Hagedoorns ('17) note that when taken at weaning the Norways (in Java) are readily tamed. The half grown animals resist taming, while the full grown, even if caught wild, tend to be more responsive. They also note the appearance of waltzing rats, similar to waltzing mice in behavior, but as viable as their normal litter-mates and able to hear.

Mus norvegicus when mature weighs 300-500 grams. Larger animals sometimes appear and our records show one male (cage bred and continually petted) which attained a maximum of 750 grams. The males in any series tend to be some 20 per cent heavier than the litter mate females.

The color above ranges from light gray or orange to brown and dark gray, usually with more or less white or light gray on the ventral surfaces. Melanic sports occasionally occur (see p. 11, note 5). Mus norvegicus is distinguished from Mus rattus, the house rat, by the following superficial characters: larger size; blunter head; smaller ears which are thicker and more covered with hair; tail shorter than body; claws usually relatively dull. Its movements are less rapid. Commonly the female Norway has twelve, sometimes fourteen nipples, while the house rat has very constantly ten.

As will be evident, the data which follow were largely obtained from caged or partially domesticated animals. For the most part however, they probably represent what would be found in the strictly wild state.

*Span of life.* The span of life of the Norway rat is not known. It seems probable that it is between three and four years, though here and there individuals may live somewhat longer. Norway rats may breed at all seasons, but best in the spring.

*Period of gestation.* 21 days Lantz ('09); 23.5-25.5 days Miller ('11). The latter periods are possibly due to the effect of nursing on gestation, see p. 21.

*Number of litters.* Miller ('11) reports seven litters in seven months from a single pair, and estimates that, in general, five to six litters may be easily reared by a single pair in a year.

*Number of young in a litter.* Climate and station appear as general modifying influences. Larger litters are reported from northern Europe than from India (Lantz, '09).

Crampe ('84) obtained an average of 10.4 in fourteen litters.

Zuschlag ('03) states that among the rats examined at Copenhagen in 1899, fetuses to the number of 14 were found four times and he himself in 1902 examined one female bearing 16. Donaldson (MS '09) also noted in a rat taken in Paris, 16 fetuses.

The India Plague Commission reports ('08) that the average number of fetuses found in females was 8.1 from a total of 12,000 Norway rats.

According to Lantz ('10) the maximum size of litters recorded in England (Field) are 17,19, 22 and 23; in India however, 14.

The maximum numbers just given as recorded in England are not trustworthy as they represent merely the number of young found in a single nest. Since two different litters are sometimes reared in the same nest the inference from the number in the nest to the number in the litter is not convincing. Lantz ('09) assumes the average litter (in north temperate latitudes) to be about 10. This is what Miller ('11) (vide infra) and Crampe ('84) (vide supra) found.

Miller ('11) observed in a group of eight litters 7–12 young in a litter, with an average of 10.5.

Recently King ('23) has studied the litter size and sex ratio in a series of caged Norways undergoing domestication.

In this instance 309 litters were examined.

In the Norway, as in the albino strain, the first litter cast is relatively small and the next two litters tend to be the largest of the series cast. In later litters the number of young gradually decreases, dropping to an average of 4.8 in the final litter of the series (table 184). The 309 litters cast by Norway females contain an average of 6.0 young: the data for the albino strain gives an average of 6.1 young per litter (table 6). The average size of the litter is therefore practically the same in the two forms; but as litter production in the albino strain is greater than that in the Norway strain, it appears that domestication has increased the fertility of the rat, as it has of many other animals (Darwin, '75).

*Weight at birth.* King ('23) found before suckling the weight at birth to be 5.34 grams for the males and 5.09 grams for the females.

*Sex ratio.* Lantz ('09) and others state that among trapped animals the males are in excess. Donaldson ('12) found the same in trapped series taken in Paris and London. In a small series trapped in Vienna however, the females were in excess.

These observations however do not indicate the sex ratio at birth.

For the total of 1862 Norway young recorded by King ('24) in table 184 the sex ratio is but 85.8 males to 100 females. This ratio is in accord with the only other sex ratio for the Norway strain that has as yet been determined, namely, the ratio of 82.1 males to 100 females found by Miller in five litters comprising fifty-one young. The sex ratio for the Norway strain is 19.4 ±3.34 points lower than that found for the stock albino strain (table 6), thus indicating that there is a significant difference between the two strains as regards the relative proportions of the sexes in the young at birth.

TABLE 184

*Data for entire series of litters cast by 88 Norway females, born and reared in captivity*

| LITTER SERIES | NUMBER OF LITTERS | NUMBER OF INDIVIDUALS | AVERAGE NUMBER OF YOUNG PER LITTER | MALES | FEMALES | NUMBER OF MALES TO 100 FEMALES |
|---|---|---|---|---|---|---|
| 1 | 88 | 462 | 5.2 | 223 | 239 | 93.3±5.86 |
| 2 | 84 | 547 | 6.5 | 253 | 294 | 86.0±4.96 |
| 3 | 63 | 410 | 6.5 | 190 | 220 | 86.3±5.75 |
| 4 | 39 | 229 | 5.9 | 106 | 123 | 86.1±7.69 |
| 5 | 20 | 128 | 6.4 | 58 | 70 | 82.8±9.91 |
| 6 | 10 | 62 | 6.2 | 21 | 41 | 51.2±9.26 |
| 7 | 5 | 24 | 4.8 | 9 | 15 | 60.0±17.17 |
| 1–7 | 309 | 1862 | 6.0 | 860 | 1002 | 85.8±2.68 |

It may be objected that the sex ratio found in this series of Norways is due to the effects of captivity on the breeding females. Data obtained in later generations of these Norways make this explanation seem improbable, and indicate that the low sex ratio in the Norways is probably normal for the strain.

*Opening of eyes.* Miller ('11) found the eyes to open at 16 or 17 days and also states that the young are weaned during the sixth week. Observations at The Institute are in agreement with these statements.

*Suckling.* The lactation period tends to be longer in the Norway than in the Albino. The range is wide but about five weeks seems to be the normal suckling period in the caged Norway. (King MS).

In King's Norways the average age at which these Norway females, as a group, began breeding was about eight months. In later generations a number of females have cast litters when from four to five months of age. In captivity the menopause in the Norway strain comes when the females are about twenty months old, though several females have cast litters when nearly two years old.

3. *Comparison of the Norway with the Albino.* To determine how the wild Norway form, as trapped in Philadelphia, differs from the albino rats in the colony at The Institute, a comparison has been made between the two forms in respect of body length, body weight, brain weight, spinal cord weight and the percentage of water in both the brain and the spinal cord (Donaldson and Hatai, '11) as well as the weights of several of the parts and viscera. (Jackson and Lowrey, '12; Hatai, '14a.)

In addition to the familiar facts that the wild Norway rat is more difficult to handle, more successful in escaping from cages and much more given to gnawing than is the Albino, that it grows bigger, breeds later, and has a longer sexual life (Crampe, '84) it is now possible to make several further statements.

At birth the caged Norway is somewhat heavier than the stock Albino (King, '15, table 1 '24) but in their relative body length and the relative weights of the brain and spinal cord, as well as in the percentage of water in these two divisions of the central nervous system, they are approximately alike at this age.

The marked differences between the two forms appear later, during the period of rapid growth. Grouping together the general differences subsequently found, we may say that the wild Norway rat is absolutely heavier, relatively slightly longer, has a relatively heavier brain and a heavier spinal cord, and since for the same body weight as a given Albino it is younger it has, when so compared, a higher percentage of water in the central nervous system.

For the same age however, the percentages of water are *nearly* alike; the percentage in the Norway rat being a trifle higher (Donaldson and Hatai, '11). The relative weights of the ovaries, testes and suprarenals are also greater (C. Watson, '07; Hatai, '14). These plus characters of the Norway tend to disappear when the Norway is subjected to domestication.

The deviations of the wild Norway may be expressed in another way. When the body weights of Norway and Albino are the same:

The wild Norway rat has a greater body length; a greater brain weight; a greater spinal cord weight; a higher percentage of water in the central nervous system; heavier ovaries, testes and suprarenals, but a smaller hypophysis.

When the body lengths are the same:

The Norway rat has a smaller body weight; a greater brain weight; a greater spinal cord weight; a higher percentage of water in the central nervous system; heavier ovaries, testes and suprarenals, but a smaller hypophysis.

Speaking generally therefore, we may say that when compared with the domesticated Albino, the wild Norway rat weighs more, is longer and possesses a nervous system in which both the brain and spinal cord are relatively larger.

These differences taken together indicate that the *albino rat* has grown less well, and it seems most natural to attribute the lack of growth to the whole set of conditions summed-up in the word 'domestication.'

The most marked difference in structure thus far described between the two forms is in the relative weight of the central nervous system. That this is due to the effects of domestication seems highly probable, in view of the observations of Darwin ('83), Lapicque and Girard ('07) and Donaldson ('23).

There are still other observations which belong here. In a study on the weight of some of the ductless glands of the Norway and of the albino rat according to sex and variety, Hatai ('14 a) an examination was made of the suprarenals, hypophysis, thyroid and gonads in both forms. The conclusions reached are given in Chapter 14.

4. *Similarity of the Norways and Albinos of western Europe to those of the United States.* It is to be noted in this connection that so far as tests have been made, the albino rats found in Western Europe are similar to those found in America. For the

Albinos from Vienna, Paris and London, the determinations were made by Donaldson ('12), and Chisolm ('11) has reported on the relation of body length to body weight in albino and pied rats in London. Chisolm compares his determinations of length with those by Donaldson ('09) and when correction is made for the slight difference in the methods of measurements, the two sets of results agree nicely.

It is also true that the wild Norways of western Europe seem to be similar to those of the United States (Donaldson, '12 a).

On the other hand the Hagedoorns ('17) report great differences among the wild Norways in Java, as shown by color, size and skull characters.

## LIFE HISTORY—NORWAY RAT: REFERENCES

*Life History.* Crampe, 1884. Donaldson and Hatai, '11. Donaldson, '12. Hagedoorn and Hagedoorn, '17. Lantz, '09. Miller, '11.

*Gestation period.* Lantz, '09. Miller, '11.

*Number of litters.* Miller, '11.

*Number in litter.* Crampe, 1884. Darwin, 1875. King, '23, '24. Lantz, '09, '10. Zuschlag, '03.

*Weight at birth.* King, '23.

*Sex ratio.* Donaldson, '12. King, '24. Lantz, '09.

*Opening of eyes and suckling.* Miller, '11.

*Comparison of Norway with Albino.* Crampe, 1884. Darwin, 1883. Donaldson and Hatai, '11. Donaldson, '23. Hatai, '14 a. Jackson and Lowrey, '12. King, '15. Lapicque and Girard, '07. Watson, '07.

*Similarities of Norways and Albinos in western Europe and United States.* Chisholm, '11. Donaldson, '09, '12, '12 a. Hagedoorn and Hagedoorn, '17.

## CHAPTER 12

# GROWTH IN TOTAL BODY WEIGHT ON AGE—CAGED NORWAYS

All data on the growth of the Norway rat must necessarily be obtained from caged animals, and although it is recognized that captivity modifies the form and functions of the animal, there is apparently no way to escape this dilemma. The growth on age of the first generation ($F_1$) of Norway rats in captivity is given by Dr. King ('23)—table 185 and charts 59 and 60.

Graphs for the body weights of stock Albinos are also given in these charts.

The coefficients of variation have been determined for this series of Norways and in table 186 these are compared with corresponding coefficients for the Albino.

These observations reveal the following relations:

Though less heavy at birth, yet from the first few days up to the fortieth day of postnatal life Norway females have an average body weight greater than that of the males. After forty days of age the males, as a rule, are heavier than the females at all age periods. This revelation of the precocity in the growth of the female is thought to be due to a greater retardation of growth in the male, owing to the excited condition in which these gray rats live during the earlier generations in captivity, and to the fact that males are more responsive to conditions, both favorable and unfavorable, than are females.

These $F_1$ Norway rats do not show the marked acceleration in body growth during early life that is characteristic of the albino strain. Increase in body weight progresses at a fairly uniform rate in both sexes until the animals are approaching senescence, the increase in the adult state being greater in the males than in the females (charts 59 and 60).

Albino rats are much heavier than these Norway rats during adolescence and early maturity; in later life the body weights of the Norways exceed those of the Albinos (charts 59 and 60), and (King '23, chart 1, p. 85).

TABLE 185

*Data for eighteen litters of* $F_1$ *Norway rats, showing the increase in the weight of the body with age*

| AGE IN DAYS | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | Body weight in grams | | | Number individuals | Body weight in grams | | | Number individuals |
| | Average | Lowest | Highest | | Average | Lowest | Highest | |
| 13 | 15.4 | 12 | 21 | 51 | 16.3 | 12 | 21 | 59 |
| 30 | 33.4 | 26 | 41 | 51 | 37.0 | 27 | 45 | 59 |
| 60 | 81.9 | 49 | 144 | 51 | 75.2 | 47 | 110 | 59 |
| 90 | 115.9 | 68 | 201 | 51 | 100.5 | 70 | 152 | 59 |
| 120 | 148.6 | 70 | 245 | 51 | 122.6 | 77 | 184 | 59 |
| 151 | 176.1 | 87 | 284 | 51 | 142.0 | 98 | 201 | 56 |
| 182 | 195.9 | 110 | 300 | 51 | 153.5 | 111 | 256 | 54 |
| 212 | 218.4 | 128 | 330 | 51 | 172.1 | 117 | 272 | 50 |
| 243 | 235.4 | 140 | 374 | 50 | 189.3 | 133 | 278 | 52 |
| 273 | 253.5 | 154 | 379 | 50 | 204.2 | 131 | 327 | 51 |
| 304 | 265.5 | 156 | 380 | 50 | 209.8 | 123 | 301 | 47 |
| 334 | 276.7 | 170 | 395 | 50 | 221.5 | 128 | 345 | 49 |
| 365 | 287.3 | 184 | 428 | 48 | 232.8 | 152 | 344 | 47 |
| 395 | 297.4 | 185 | 442 | 48 | 242.3 | 135 | 383 | 47 |
| 425 | 312.2 | 200 | 457 | 47 | 247.5 | 156 | 380 | 43 |
| 455 | 322.3 | 188 | 471 | 47 | 260.5 | 172 | 359 | 44 |
| 486 | 332.0 | 226 | 459 | 46 | 257.9 | 182 | 382 | 43 |
| 516 | 335.0 | 226 | 476 | 43 | 264.1 | 163 | 373 | 37 |
| 547 | 345.6 | 231 | 486 | 41 | 261.5 | 173 | 375 | 36 |
| 578 | 358.0 | 233 | 516 | 39 | 266.5 | 168 | 360 | 34 |
| 608 | 361.8 | 231 | 518 | 38 | 271.9 | 184 | 339 | 31 |
| 639 | 369.9 | 236 | 540 | 37 | 279.7 | 190 | 367 | 30 |
| 670 | 374.5 | 240 | 546 | 37 | 284.4 | 210 | 355 | 26 |
| 700 | 364.2 | 243 | 518 | 34 | 283.4 | 200 | 376 | 25 |
| 730 | 362.1 | 231 | 505 | 27 | 278.9 | 197 | 341 | 19 |

It seems probable that the slow growth of the Norways during early life is characteristic for the strain, and that the acceleration in the growth of the Albinos is one of the results of domestication.

Norway rats show a high degree of variability in body weight at all age periods (table 186). In early life the females are

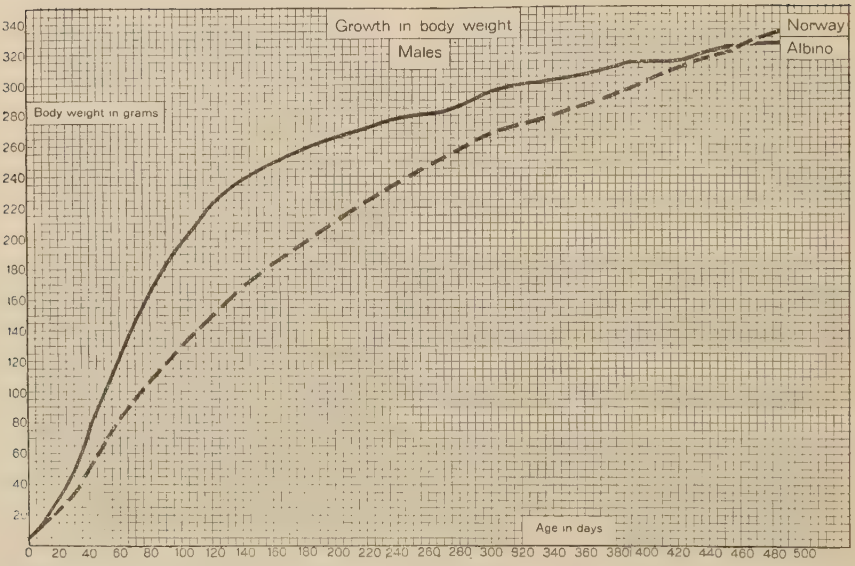

Chart 59 Graphs showing the growth in body weight of Norway and of stock albino males (data in table 1, and in table 3 of a previous paper; King, '15 a).

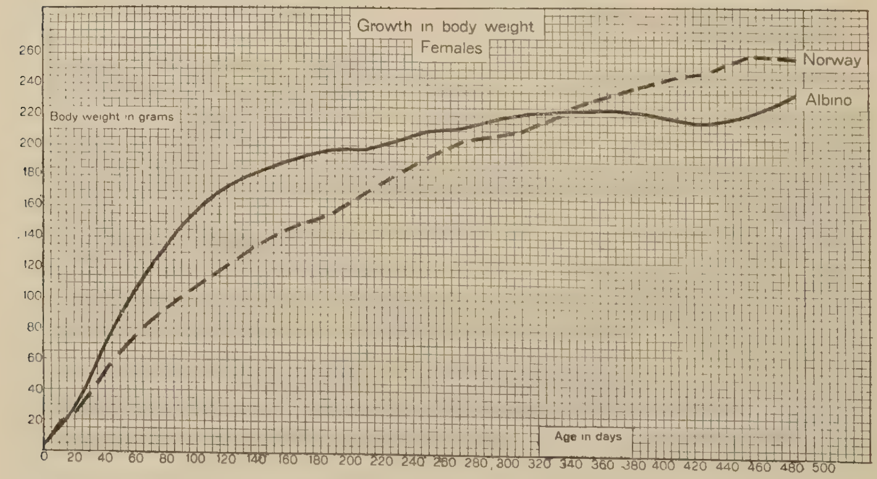

Chart 60 Graphs showing the growth in body weight of Norway and of stock albino females (data in table 1, and in table 3 of a previous paper; King, '15 a).

somewhat more variable than the males, but in the adult state the males tend to be more variable.

TABLE 186

*Showing the coefficients of variation with their probable error for the body weights at different ages of a series of Norway rats (51 males and 59 females), and of a series of stock albino rats (50 males and 67 females).*

| AGE IN DAYS | NORWAY SERIES | | ALBINO SERIES | |
|---|---|---|---|---|
| | Males | Females | Males | Females |
| 13 | 12.2±0.82 | 14.6±0.90 | 11.8±0.79 | 11.4±0.76 |
| 30 | 13.0±0.86 | 17.3±1.07 | 10.2±0.68 | 11.0±0.74 |
| 60 | 24.1±1.60 | 19.8±1.22 | 17.0±1.14 | 15.7±1.05 |
| 90 | 26.2±1.74 | 16.9±1.04 | 14.8±0.99 | 12.5±0.95 |
| 120 | 28.2±1.88 | 16.0±0.99 | 13.4±0.90 | 10.3±0.75 |
| 151 | 24.2±1.61 | 16.6±1.03 | 13.3±0.89 | 10.4±0.73 |
| 182 | 23.4±1.55 | 17.8±1.13 | 14.2±1.22 | 12.3±0.90 |
| 212 | 21.8±1.45 | 17.9±1.20 | 14.0±0.96 | 12.4±0.91 |
| 243 | 23.7±1.60 | 18.2±1.26 | 13.9±0.99 | 12.6±0.91 |
| 273 | 22.4±1.50 | 19.1±1.27 | 13.4±0.99 | 11.5±0.89 |
| 304 | 21.5±1.45 | 19.9±1.38 | 14.0±1.11 | 10.3±0.79 |
| 334 | 19.8±1.33 | 20.6±1.40 | 13.7±1.13 | 10.8±0.87 |
| 365 | 19.5±1.33 | 20.4±1.41 | 13.0±1.16 | 10.7±0.91 |
| 395 | 19.5±1.34 | 22.3±1.54 | 12.6±1.22 | 11.5±0.98 |
| 425 | 17.6±1.22 | 21.1±1.47 | 13.4±1.32 | 10.9±0.94 |
| 455 | 19.2±1.32 | 18.9±1.35 | 13.6±1.67 | 8.9±0.99 |
| 486 | 17.3±1.21 | 19.5±1.41 | 15.0±2.06 | 13.4±1.77 |
| 516 | 17.4±1.26 | 18.3±1.43 | | |
| 547 | 16.7±1.24 | 19.4±1.54 | | |
| 578 | 18.3±1.39 | 16.4±1.34 | | |
| 608 | 17.1±1.32 | 15.3±1.28 | | |
| 639 | 17.4±1.36 | 15.8±1.37 | | |
| 670 | 17.5±1.39 | 14.2±1.32 | | |
| 700 | 17.7±1.36 | 11.9±1.14 | | |
| 730 | 19.4±1.79 | 13.9±1.52 | | |

Norway rats at all age periods are much more variable in body weight than are albino rats (table 186).

# CHAPTER 13

# GROWTH IN TOTAL BODY WEIGHT ON BODY LENGTH AND GROWTH IN THE WEIGHT OF PARTS AND SYSTEMS OF THE BODY

1. Total body weight between birth and maturity on body length. 2. Growth of parts. 3. Growth of systems. 4. Weight of cranium.

1. *Total body weight between birth and maturity on body length—wild Norway rats.* *Body length on body weight.* From the study of 282 male and 318 wild female Norway rats, trapped in Philadelphia, measurements have been taken for body weight and body length (Donaldson and Hatai, '11).

The values for body length—sexes combined—on body weight are given by formula (53.) In chart 61 the corresponding graph is given and for comparison the graph for the body length of the Albino is also drawn (see formula 4).

At 450 grams the body length of the wild Norway is about 4 per cent above that of the Albino.

It has been found that for a given body weight, the body length is in the male Norway 0.4 per cent above the mean, and in the female 0.4 per cent below (Donaldson and Hatai, '11, p. 425).

Table 187 contains values for body weights and for the tail length and the weights of the brain and the spinal cord computed by the formulas devised by Hatai.

*Body weight on body length.* When the formula (53) is transformed so as to give the body weight for a given body length and the correction for sex is included, we have for the males formula (54) and for the females formula (55). In chart 62 are given the graphs for both sexes. As in the case of the Albino, the body weight for the male is slightly below that for the female of like body weight.

*Tail length on body length.* The tail length on the body length has been determined by Hatai (MS '14) and is represented by formulas (56) and (57) for the male and female respectively. As can be seen by consulting table 187, the males have the shorter tails—a relation which is somewhat less marked than that found for the Albino. In chart 63 are given the corresponding graphs.

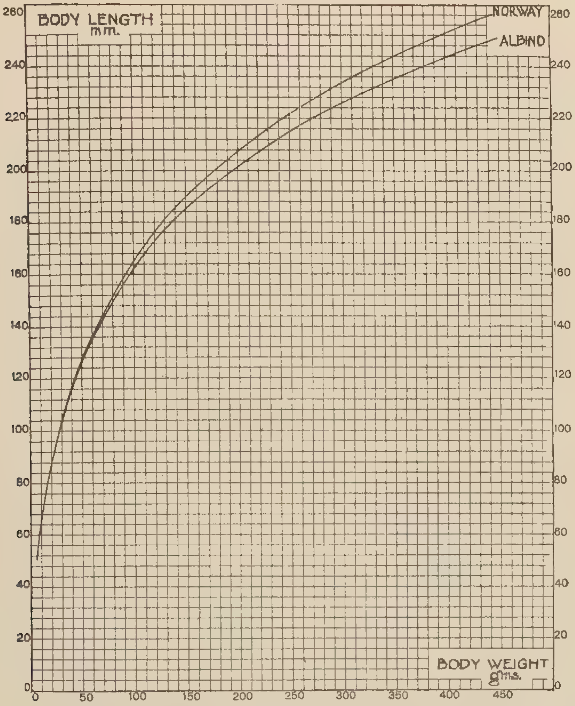

Chart 61 Norway rat—Giving body length on the body weight. Males only. Formula (53), table 187. Inserted for comparison is the corresponding graph for the male Albino (see formula (4)).

*Weight-length ratios.* In table 188 are given the values for the Norway obtained by dividing the body weight by the body length, as these appear in table 187. The ratios in table 188 are consistently smaller than those for the Albino (table 122) as the Norway is longer for a given body weight. Further, the values for the two sexes in the Norway are more alike than in the Albino.

TABLE 187

*Gives the tail length, body weight, brain weight and spinal cord weight for each millimeter of body length of the male and female Norway rat respectively.*

*See charts 61, 62, 63 and 64.*

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight of | | Tail length | Body weight | Weight of | |
| | | | Brain | Spinal cord | | | Brain | Spinal cord |
| *mm.* | *mm.* | *gms.* | *gms.* | *gms.* | *mm.* | *gms.* | *gms.* | *gms.* |
| 50 | 15.0 | 4.4 | | 0.031 | 16.0 | 4.6 | | 0.032 |
| 51 | 16.2 | 4.8 | | 0.034 | 17.2 | 4.9 | | 0.035 |
| 52 | 17.3 | 5.1 | 0.270 | 0.037 | 18.4 | 5.2 | 0.307 | 0.038 |
| 53 | 18.5 | 5.4 | 0.367 | 0.040 | 19.6 | 5.6 | 0.393 | 0.041 |
| 54 | 19.6 | 5.8 | 0.443 | 0.043 | 20.8 | 5.9 | 0.462 | 0.044 |
| 55 | 20.8 | 6.1 | 0.508 | 0.046 | 21.9 | 6.3 | 0.522 | 0.047 |
| 56 | 21.9 | 6.5 | 0.563 | 0.049 | 23.1 | 6.6 | 0.574 | 0.050 |
| 57 | 23.0 | 6.8 | 0.611 | 0.052 | 24.3 | 7.0 | 0.620 | 0.053 |
| 58 | 24.1 | 7.2 | 0.655 | 0.055 | 25.4 | 7.4 | 0.661 | 0.056 |
| 59 | 25.3 | 7.6 | 0.694 | 0.058 | 26.5 | 7.7 | 0.698 | 0.059 |
| 60 | 26.4 | 7.9 | 0.730 | 0.061 | 27.7 | 8.1 | 0.732 | 0.063 |
| 61 | 27.5 | 8.3 | 0.763 | 0.064 | 28.8 | 8.5 | 0.763 | 0.066 |
| 62 | 28.6 | 8.7 | 0.794 | 0.067 | 29.9 | 8.9 | 0.793 | 0.069 |
| 63 | 29.7 | 9.1 | 0.823 | 0.070 | 31.1 | 9.3 | 0.820 | 0.072 |
| 64 | 30.8 | 9.5 | 0.850 | 0.074 | 32.2 | 9.7 | 0.846 | 0.075 |
| 65 | 31.9 | 9.9 | 0.875 | 0.077 | 33.3 | 10.1 | 0.871 | 0.078 |
| 66 | 32.9 | 10.3 | 0.900 | 0.080 | 34.4 | 10.5 | 0.894 | 0.082 |
| 67 | 34.0 | 10.7 | 0.923 | 0.083 | 35.5 | 10.9 | 0.916 | 0.085 |
| 68 | 35.1 | 11.1 | 0.944 | 0.086 | 36.6 | 11.3 | 0.937 | 0.088 |
| 69 | 36.2 | 11.5 | 0.965 | 0.090 | 37.7 | 11.8 | 0.957 | 0.091 |
| 70 | 37.2 | 11.9 | 0.985 | 0.093 | 38.8 | 12.2 | 0.977 | 0.095 |
| 71 | 38.3 | 12.4 | 1.005 | 0.096 | 39.9 | 12.6 | 0.995 | 0.098 |
| 72 | 39.4 | 12.8 | 1.023 | 0.099 | 41.0 | 13.1 | 1.013 | 0.101 |
| 73 | 40.4 | 13.3 | 1.041 | 0.103 | 42.1 | 13.5 | 1.031 | 0.104 |
| 74 | 41.5 | 13.7 | 1.059 | 0.106 | 43.1 | 14.0 | 1.048 | 0.108 |
| 75 | 42.5 | 14.2 | 1.075 | 0.109 | 44.2 | 14.5 | 1.064 | 0.111 |
| 76 | 43.6 | 14.7 | 1.092 | 0.113 | 45.3 | 14.9 | 1.080 | 0.114 |
| 77 | 44.6 | 15.1 | 1.107 | 0.116 | 46.4 | 15.4 | 1.095 | 0.118 |
| 78 | 45.7 | 15.6 | 1.123 | 0.119 | 47.4 | 15.9 | 1.110 | 0.121 |
| 79 | 46.7 | 16.1 | 1.138 | 0.123 | 48.5 | 16.4 | 1.124 | 0.125 |
| 80 | 47.7 | 16.6 | 1.152 | 0.126 | 49.5 | 16.9 | 1.138 | 0.128 |
| 81 | 48.8 | 17.1 | 1.166 | 0.129 | 50.6 | 17.4 | 1.152 | 0.131 |
| 82 | 49.8 | 17.6 | 1.180 | 0.133 | 51.7 | 17.9 | 1.166 | 0.135 |

TABLE 187—Continued

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight of | | Tail length | Body weight | Weight of | |
| | | | Brain | Spinal cord | | | Brain | Spinal cord |
| *mm.* | *mm.* | *gms.* | *gms.* | *gms.* | *mm.* | *gms.* | *gms.* | *gms.* |
| 83 | 50.8 | 18.1 | 1.194 | 0.136 | 52.7 | 18.5 | 1.179 | 0.138 |
| 84 | 51.9 | 18.7 | 1.207 | 0.140 | 53.8 | 19.0 | 1.192 | 0.142 |
| 85 | 52.9 | 19.2 | 1.220 | 0.143 | 54.8 | 19.6 | 1.204 | 0.145 |
| 86 | 53.9 | 19.7 | 1.232 | 0.146 | 55.8 | 20.1 | 1.216 | 0.149 |
| 87 | 54.9 | 20.3 | 1.245 | 0.150 | 56.9 | 20.7 | 1.229 | 0.152 |
| 88 | 55.9 | 20.8 | 1.257 | 0.153 | 57.9 | 21.2 | 1.240 | 0.156 |
| 89 | 57.0 | 21.4 | 1.269 | 0.157 | 59.0 | 21.8 | 1.252 | 0.159 |
| 90 | 58.0 | 22.0 | 1.281 | 0.160 | 60.0 | 22.4 | 1.264 | 0.163 |
| 91 | 59.0 | 22.5 | 1.292 | 0.164 | 61.0 | 23.0 | 1.275 | 0.166 |
| 92 | 60.0 | 23.1 | 1.303 | 0.167 | 62.1 | 23.6 | 1.286 | 0.170 |
| 93 | 61.0 | 23.7 | 1.315 | 0.171 | 63.1 | 24.2 | 1.297 | 0.173 |
| 94 | 62.0 | 24.3 | 1.325 | 0.174 | 64.1 | 24.8 | 1.307 | 0.177 |
| 95 | 63.0 | 25.0 | 1.336 | 0.178 | 65.1 | 25.4 | 1.318 | 0.180 |
| 96 | 64.0 | 25.6 | 1.347 | 0.181 | 66.1 | 26.1 | 1.328 | 0.184 |
| 97 | 65.0 | 26.2 | 1.357 | 0.185 | 67.2 | 26.7 | 1.338 | 0.188 |
| 98 | 66.0 | 26.9 | 1.368 | 0.189 | 68.2 | 27.4 | 1.348 | 0.191 |
| 99 | 67.0 | 27.5 | 1.378 | 0.192 | 69.2 | 28.0 | 1.358 | 0.195 |
| 100 | 68.0 | 28.2 | 1.388 | 0.196 | 70.2 | 28.7 | 1.368 | 0.198 |
| 101 | 69.0 | 28.8 | 1.398 | 0.199 | 71.2 | 29.4 | 1.378 | 0.202 |
| 102 | 70.0 | 29.5 | 1.408 | 0.203 | 72.2 | 30.1 | 1.388 | 0.206 |
| 103 | 71.0 | 30.2 | 1.417 | 0.207 | 73.2 | 30.8 | 1.397 | 0.209 |
| 104 | 72.0 | 30.9 | 1.427 | 0.210 | 74.2 | 31.5 | 1.406 | 0.213 |
| 105 | 73.0 | 31.6 | 1.436 | 0.214 | 75.2 | 32.2 | 1.416 | 0.217 |
| 106 | 73.9 | 32.3 | 1.446 | 0.218 | 76.2 | 33.0 | 1.425 | 0.220 |
| 107 | 74.9 | 33.1 | 1.455 | 0.221 | 77.2 | 33.7 | 1.434 | 0.224 |
| 108 | 75.9 | 33.8 | 1.464 | 0.225 | 78.2 | 34.5 | 1.443 | 0.228 |
| 109 | 76.9 | 34.6 | 1.473 | 0.229 | 79.2 | 35.2 | 1.452 | 0.232 |
| 110 | 77.9 | 35.3 | 1.482 | 0.232 | 80.2 | 36.0 | 1.460 | 0.235 |
| 111 | 78.8 | 36.1 | 1.491 | 0.236 | 81.2 | 36.8 | 1.469 | 0.239 |
| 112 | 79.8 | 36.9 | 1.499 | 0.240 | 82.2 | 37.6 | 1.477 | 0.243 |
| 113 | 80.8 | 37.7 | 1.508 | 0.244 | 83.2 | 38.4 | 1.486 | 0.247 |
| 114 | 81.8 | 38.5 | 1.517 | 0.247 | 84.2 | 39.3 | 1.494 | 0.250 |
| 115 | 82.7 | 39.3 | 1.525 | 0.251 | 85.2 | 40.1 | 1.503 | 0.254 |
| 116 | 83.7 | 40.2 | 1.534 | 0.255 | 86.2 | 40.9 | 1.511 | 0.258 |
| 117 | 84.7 | 41.0 | 1.542 | 0.259 | 87.2 | 41.8 | 1.519 | 0.262 |
| 118 | 85.6 | 41.9 | 1.550 | 0.262 | 88.1 | 42.7 | 1.527 | 0.266 |

TABLE 187—Continued

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight of | | Tail length | Body weight | Weight of | |
| | | | Brain | Spinal cord | | | Brain | Spinal cord |
| *mm.* | *mm.* | *gms.* | *gms.* | *gms.* | *mm.* | *gms.* | *gms.* | *gms.* |
| 119 | 86.6 | 42.7 | 1.558 | 0.266 | 89.1 | 43.6 | 1.535 | 0.269 |
| 120 | 87.6 | 43.6 | 1.567 | 0.270 | 90.1 | 44.5 | 1.543 | 0.273 |
| 121 | 88.5 | 44.5 | 1.575 | 0.274 | 91.1 | 45.4 | 1.551 | 0.277 |
| 122 | 89.5 | 45.4 | 1.583 | 0.278 | 92.1 | 46.3 | 1.559 | 0.281 |
| 123 | 90.5 | 46.3 | 1.591 | 0.281 | 93.0 | 47.3 | 1.567 | 0.285 |
| 124 | 91.4 | 47.3 | 1.599 | 0.285 | 94.0 | 48.2 | 1.575 | 0.289 |
| 125 | 92.4 | 48.2 | 1.606 | 0.289 | 95.0 | 49.2 | 1.582 | 0.292 |
| 126 | 93.4 | 49.2 | 1.614 | 0.293 | 96.0 | 50.2 | 1.590 | 0.296 |
| 127 | 94.3 | 50.2 | 1.622 | 0.297 | 96.9 | 51.2 | 1.598 | 0.300 |
| 128 | 95.3 | 51.1 | 1.630 | 0.301 | 97.9 | 52.2 | 1.605 | 0.304 |
| 129 | 96.2 | 52.1 | 1.637 | 0.305 | 98.9 | 53.2 | 1.613 | 0.308 |
| 130 | 97.2 | 53.2 | 1.645 | 0.308 | 99.8 | 54.2 | 1.620 | 0.312 |
| 131 | 98.1 | 54.2 | 1.652 | 0.312 | 100.8 | 55.3 | 1.627 | 0.316 |
| 132 | 99.1 | 55.3 | 1.660 | 0.316 | 101.8 | 56.4 | 1.635 | 0.320 |
| 133 | 100.0 | 56.3 | 1.667 | 0.320 | 102.7 | 57.5 | 1.642 | 0.324 |
| 134 | 101.0 | 57.4 | 1.675 | 0.324 | 103.7 | 58.6 | 1.649 | 0.328 |
| 135 | 101.9 | 58.5 | 1.682 | 0.328 | 104.7 | 59.7 | 1.657 | 0.332 |
| 136 | 102.9 | 59.6 | 1.689 | 0.332 | 105.6 | 60.9 | 1.664 | 0.336 |
| 137 | 103.8 | 60.7 | 1.697 | 0.336 | 106.6 | 62.0 | 1.671 | 0.339 |
| 138 | 104.8 | 61.9 | 1.704 | 0.340 | 107.5 | 63.2 | 1.678 | 0.343 |
| 139 | 105.7 | 63.0 | 1.711 | 0.344 | 108.5 | 64.3 | 1.685 | 0.347 |
| 140 | 106.7 | 64.2 | 1.718 | 0.348 | 109.5 | 65.6 | 1.692 | 0.351 |
| 141 | 107.6 | 65.4 | 1.725 | 0.352 | 110.4 | 66.8 | 1.699 | 0.355 |
| 142 | 108.6 | 66.6 | 1.732 | 0.356 | 111.4 | 68.0 | 1.706 | 0.359 |
| 143 | 109.5 | 67.8 | 1.739 | 0.360 | 112.3 | 69.3 | 1.713 | 0.363 |
| 144 | 110.5 | 69.1 | 1.746 | 0.363 | 113.3 | 70.6 | 1.720 | 0.368 |
| 145 | 111.4 | 70.4 | 1.753 | 0.367 | 114.2 | 71.9 | 1.727 | 0.372 |
| 146 | 112.3 | 71.6 | 1.760 | 0.371 | 115.2 | 73.2 | 1.733 | 0.376 |
| 147 | 113.3 | 72.9 | 1.767 | 0.375 | 116.1 | 74.5 | 1.740 | 0.380 |
| 148 | 114.2 | 74.3 | 1.774 | 0.379 | 117.1 | 75.9 | 1.747 | 0.384 |
| 149 | 115.2 | 75.6 | 1.781 | 0.384 | 118.0 | 77.2 | 1.754 | 0.388 |
| 150 | 116.1 | 77.0 | 1.788 | 0.388 | 119.0 | 78.6 | 1.760 | 0.392 |
| 151 | 117.0 | 78.3 | 1.794 | 0.392 | 119.9 | 80.0 | 1.767 | 0.396 |
| 152 | 118.0 | 79.7 | 1.801 | 0.396 | 120.9 | 81.5 | 1.774 | 0.400 |
| 153 | 118.9 | 81.2 | 1.808 | 0.400 | 121.8 | 82.9 | 1.780 | 0.404 |

TABLE 187—Continued

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight of | | Tail length | Body weight | Weight of | |
| | | | Brain | Spinal cord | | | Brain | Spinal cord |
| *mm.* | *mm.* | *gms.* | *gms.* | *gms.* | *mm.* | *gms.* | *gms.* | *gms.* |
| 154 | 119.8 | 82.6 | 1.815 | 0.404 | 122.8 | 84.4 | 1.787 | 0.408 |
| 155 | 120.8 | 84.1 | 1.821 | 0.408 | 123.7 | 85.9 | 1.793 | 0.412 |
| 156 | 121.7 | 85.6 | 1.828 | 0.412 | 124.7 | 87.4 | 1.800 | 0.416 |
| 157 | 122.6 | 87.1 | 1.835 | 0.416 | 125.6 | 89.0 | 1.807 | 0.420 |
| 158 | 123.6 | 88.6 | 1.841 | 0.420 | 126.6 | 90.6 | 1.813 | 0.424 |
| 159 | 124.5 | 90.1 | 1.848 | 0.424 | 127.5 | 92.1 | 1.819 | 0.429 |
| 160 | 125.4 | 91.7 | 1.854 | 0.428 | 128.4 | 93.8 | 1.826 | 0.433 |
| 161 | 126.4 | 93.3 | 1.861 | 0.432 | 129.4 | 95.4 | 1.832 | 0.437 |
| 162 | 127.3 | 94.9 | 1.867 | 0.436 | 130.3 | 97.1 | 1.839 | 0.441 |
| 163 | 128.2 | 96.6 | 1.874 | 0.441 | 131.3 | 98.7 | 1.845 | 0.445 |
| 164 | 129.1 | 98.2 | 1.880 | 0.445 | 132.2 | 100.5 | 1.851 | 0.449 |
| 165 | 130.1 | 99.9 | 1.887 | 0.449 | 133.1 | 102.2 | 1.858 | 0.453 |
| 166 | 131.0 | 101.6 | 1.893 | 0.453 | 134.1 | 104.1 | 1.864 | 0.458 |
| 167 | 131.9 | 103.4 | 1.899 | 0.457 | 135.0 | 105.7 | 1.870 | 0.462 |
| 168 | 132.8 | 105.1 | 1.906 | 0.461 | 135.9 | 107.5 | 1.877 | 0.466 |
| 169 | 133.8 | 106.9 | 1.912 | 0.465 | 136.9 | 109.4 | 1.883 | 0.470 |
| 170 | 134.7 | 108.7 | 1.918 | 0.469 | 137.8 | 111.3 | 1.889 | 0.474 |
| 171 | 135.6 | 110.6 | 1.925 | 0.474 | 138.8 | 113.1 | 1.895 | 0.478 |
| 172 | 136.5 | 112.4 | 1.931 | 0.478 | 139.7 | 115.1 | 1.901 | 0.483 |
| 173 | 137.5 | 114.3 | 1.937 | 0.482 | 140.6 | 117.0 | 1.908 | 0.487 |
| 174 | 138.4 | 116.3 | 1.944 | 0.486 | 141.5 | 119.0 | 1.914 | 0.491 |
| 175 | 139.3 | 118.2 | 1.950 | 0.490 | 142.5 | 121.0 | 1.920 | 0.495 |
| 176 | 140.2 | 120.2 | 1.956 | 0.494 | 143.4 | 123.0 | 1.926 | 0.499 |
| 177 | 141.1 | 122.2 | 1.962 | 0.499 | 144.3 | 125.1 | 1.932 | 0.504 |
| 178 | 142.1 | 124.2 | 1.968 | 0.503 | 145.3 | 127.2 | 1.938 | 0.508 |
| 179 | 143.0 | 126.3 | 1.975 | 0.507 | 146.2 | 129.3 | 1.9 4 | 0.512 |
| 180 | 143.9 | 128.4 | 1.981 | 0.511 | 147.1 | 131.5 | 1.949 | 0.516 |
| 181 | 144.8 | 130.5 | 1.987 | 0.515 | 148.1 | 133.7 | 1.955 | 0.520 |
| 182 | 145.7 | 132.7 | 1.993 | 0.520 | 149.0 | 135.9 | 1.962 | 0.525 |
| 183 | 146.7 | 134.9 | 1.999 | 0.524 | 149.9 | 138.1 | 1.968 | 0.529 |
| 184 | 147.6 | 137.1 | 2.005 | 0.528 | 150.8 | 140.4 | 1.974 | 0.533 |
| 185 | 148.5 | 139.3 | 2.011 | 0.532 | 151.8 | 142.8 | 1.980 | 0.537 |
| 186 | 149.4 | 141.6 | 2.017 | 0.536 | 152.7 | 145.1 | 1.986 | 0.542 |
| 187 | 150.3 | 144.0 | 2.023 | 0.541 | 153.6 | 147.5 | 1.992 | 0.546 |
| 188 | 151.2 | 146.3 | 2.029 | 0.545 | 154.5 | 149.9 | 1.998 | 0.550 |
| 189 | 152.2 | 148.7 | 2.035 | 0.549 | 155.5 | 152.4 | 2.004 | 0.554 |
| 190 | 153.1 | 151.1 | 2.042 | 0.553 | 156.4 | 154.9 | 2.010 | 0.559 |

TABLE 187—Continued

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight of | | Tail length | Body weight | Weight of | |
| | | | Brain | Spinal cord | | | Brain | Spinal cord |
| mm. | mm. | gms. | gms. | gms. | mm. | gms. | gms. | gms. |
| 191 | 154.0 | 153.6 | 2.047 | 0.557 | 157.3 | 157.4 | 2.016 | 0.563 |
| 192 | 154.9 | 156.1 | 2.053 | 0.562 | 158.2 | 160.0 | 2.022 | 0.567 |
| 193 | 155.8 | 158.6 | 2.059 | 0.566 | 159.1 | 162.6 | 2.028 | 0.572 |
| 194 | 156.7 | 161.2 | 2.065 | 0.570 | 160.1 | 165.2 | 2.034 | 0.576 |
| 195 | 157.6 | 163.8 | 2.071 | 0.575 | 161.0 | 167.9 | 2.039 | 0.580 |
| 196 | 158.5 | 166.4 | 2.077 | 0.579 | 161.9 | 170.6 | 2.045 | 0.584 |
| 197 | 159.4 | 169.1 | 2.083 | 0.583 | 162.8 | 173.4 | 2.051 | 0.589 |
| 198 | 160.4 | 171.8 | 2.089 | 0.587 | 163.7 | 176.2 | 2.057 | 0.593 |
| 199 | 161.3 | 174.6 | 2.095 | 0.592 | 164.7 | 179.1 | 2.063 | 0.597 |
| 200 | 162.2 | 177.4 | 2.101 | 0.596 | 165.6 | 181.9 | 2.069 | 0.602 |
| 201 | 163.1 | 180.2 | 2.107 | 0.600 | 166.5 | 184.9 | 2.074 | 0.606 |
| 202 | 164.0 | 183.1 | 2.112 | 0.604 | 167.4 | 187.8 | 2.080 | 0.610 |
| 203 | 164.9 | 186.0 | 2.118 | 0.609 | 168.3 | 190.9 | 2.086 | 0.615 |
| 204 | 165.8 | 189.0 | 2.124 | 0.613 | 169.2 | 193.9 | 2.092 | 0.619 |
| 205 | 166.7 | 192.0 | 2.130 | 0.617 | 170.2 | 197.0 | 2.098 | 0.623 |
| 206 | 167.6 | 195.0 | 2.136 | 0.622 | 171.1 | 200.2 | 2.103 | 0.628 |
| 207 | 168.5 | 198.1 | 2.142 | 0.626 | 172.0 | 203.4 | 2.109 | 0.632 |
| 208 | 169.4 | 201.3 | 2.148 | 0.630 | 172.9 | 206.6 | 2.115 | 0.636 |
| 209 | 170.3 | 204.4 | 2.153 | 0.635 | 173.8 | 209.9 | 2.120 | 0.641 |
| 210 | 171.2 | 207.7 | 2.159 | 0.639 | 174.7 | 213.2 | 2.126 | 0.645 |
| 211 | 172.1 | 210.9 | 2.165 | 0.643 | 175.6 | 216.6 | 2.132 | 0.649 |
| 212 | 173.1 | 214.3 | 2.171 | 0.647 | 176.6 | 220.1 | 2.138 | 0.654 |
| 213 | 174.0 | 217.7 | 2.177 | 0.652 | 177.5 | 223.5 | 2.143 | 0.658 |
| 214 | 174.9 | 221.1 | 2.182 | 0.656 | 178.4 | 227.1 | 2.149 | 0.662 |
| 215 | 175.8 | 224.5 | 2.188 | 0.660 | 179.3 | 230.7 | 2.155 | 0.667 |
| 216 | 176.7 | 228.1 | 2.194 | 0.665 | 180.2 | 234.3 | 2.160 | 0.671 |
| 217 | 177.6 | 231.6 | 2.199 | 0.669 | 181.1 | 238.0 | 2.166 | 0.675 |
| 218 | 178.5 | 235.3 | 2.205 | 0.673 | 182.0 | 241.8 | 2.171 | 0.680 |
| 219 | 179.4 | 239.0 | 2.211 | 0.678 | 182.9 | 245.6 | 2.177 | 0.684 |
| 220 | 180.3 | 242.7 | 2.217 | 0.682 | 183.8 | 249.4 | 2.183 | 0.689 |
| 221 | 181.2 | 246.5 | 2.222 | 0.686 | 184.8 | 253.3 | 2.188 | 0.693 |
| 222 | 182.1 | 250.3 | 2.228 | 0.691 | 185.7 | 257.3 | 2.194 | 0.697 |
| 223 | 183.0 | 254.2 | 2.234 | 0.695 | 186.6 | 261.3 | 2.199 | 0.702 |
| 224 | 183.9 | 258.2 | 2.239 | 0.699 | 187.5 | 265.4 | 2.205 | 0.706 |
| 225 | 184.8 | 262.2 | 2.245 | 0.704 | 188.4 | 269.6 | 2.211 | 0.710 |
| 226 | 185.7 | 266.3 | 2.251 | 0.708 | 189.3 | 273.8 | 2.216 | 0.715 |
| 227 | 186.6 | 270.4 | 2.256 | 0.713 | 190.2 | 278.1 | 2.222 | 0.719 |

TABLE 187—Concluded

| MALES | | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| Body length | Tail length | Body weight | Weight of | | Tail length | Body weight | Weight of | |
| | | | Brain | Spinal cord | | | Brain | Spinal cord |
| *mm.* | *mm.* | *gms.* | *gms.* | *gms.* | *mm.* | *gms.* | *gms.* | *gms.* |
| 228 | 187.5 | 274.6 | 2.262 | 0.717 | 191.1 | 282.4 | 2.227 | 0.724 |
| 229 | 188.4 | 278.8 | 2.268 | 0.721 | 192.0 | 286.8 | 2.233 | 0.728 |
| 230 | 189.3 | 283.1 | 2.273 | 0.726 | 192.9 | 291.3 | 2.238 | 0.732 |
| 231 | 190.2 | 287.5 | 2.279 | 0.730 | 193.8 | 295.8 | 2.244 | 0.737 |
| 232 | 191.1 | 292.0 | 2.285 | 0.734 | 194.7 | 300.4 | 2.250 | 0.741 |
| 233 | 192.0 | 296.5 | 2.290 | 0.739 | 195.6 | 305.1 | 2.255 | 0.746 |
| 234 | 192.9 | 301.0 | 2.296 | 0.743 | 196.5 | 309.8 | 2.261 | 0.750 |
| 235 | 193.8 | 305.7 | 2.301 | 0.748 | 197.4 | 314.6 | 2.266 | 0.754 |
| 236 | 194.7 | 310.4 | 2.307 | 0.752 | 198.3 | 319.5 | 2.272 | 0.759 |
| 237 | 195.5 | 315.1 | 2.312 | 0.756 | 199.2 | 324.4 | 2.277 | 0.763 |
| 238 | 196.4 | 320.0 | 2.318 | 0.761 | 200.1 | 329.4 | 2.283 | 0.768 |
| 239 | 197.3 | 324.9 | 2.324 | 0.765 | 201.1 | 334.5 | 2.288 | 0.772 |
| 240 | 198.2 | 329.9 | 2.329 | 0.769 | 202.0 | 339.7 | 2.294 | 0.776 |
| 241 | 199.1 | 334.9 | 2.335 | 0.774 | 202.9 | 344.9 | 2.299 | 0.781 |
| 242 | 200.0 | 340.1 | 2.340 | 0.778 | 203.8 | 350.2 | 2.305 | 0.785 |
| 243 | 200.9 | 345.3 | 2.346 | 0.783 | 204.7 | 355.6 | 2.310 | 0.790 |
| 244 | 201.8 | 350.5 | 2.351 | 0.787 | 205.6 | 361.1 | 2.316 | 0.794 |
| 245 | 202.7 | 355.9 | 2.357 | 0.791 | 206.5 | 366.7 | 2.321 | 0.799 |
| 246 | 203.6 | 361.3 | 2.363 | 0.796 | 207.4 | 372.3 | 2.327 | 0.803 |
| 247 | 204.5 | 366.8 | 2.368 | 0.800 | 208.3 | 378.0 | 2.332 | 0.807 |
| 248 | 205.4 | 372.4 | 2.374 | 0.805 | 209.2 | 383.8 | 2.337 | 0.812 |
| 249 | 206.3 | 378.1 | 2.379 | 0.809 | 210.1 | 389.7 | 2.343 | 0.816 |
| 250 | 207.2 | 383.9 | 2.385 | 0.813 | 211.0 | 395.7 | 2.349 | 0.821 |
| 251 | | 389.7 | 2.390 | 0.818 | | 401.7 | 2.354 | 0.825 |
| 252 | | 395.6 | 2.396 | 0.822 | | 407.9 | 2.359 | 0.830 |
| 253 | | 401.6 | 2.401 | 0.827 | | 414.1 | 2.365 | 0.834 |
| 254 | | 407.7 | 2.407 | 0.831 | | 420.4 | 2.370 | 0.838 |
| 255 | | 413.9 | 2.412 | 0.835 | | 426.9 | 2.376 | 0.843 |
| 256 | | 420.2 | 2.418 | 0.840 | | 433.4 | 2.381 | 0.847 |
| 257 | | 426.5 | 2.423 | 0.844 | | 440.0 | 2.386 | 0.852 |
| 258 | | 433.0 | 2.429 | 0.849 | | 446.7 | 2.392 | 0.856 |
| 259 | | 439.6 | 2.434 | 0.853 | | 453.5 | 2.397 | 0.861 |
| 260 | | 446.2 | 2.440 | 0.858 | | 460.4 | 2.403 | 0.865 |

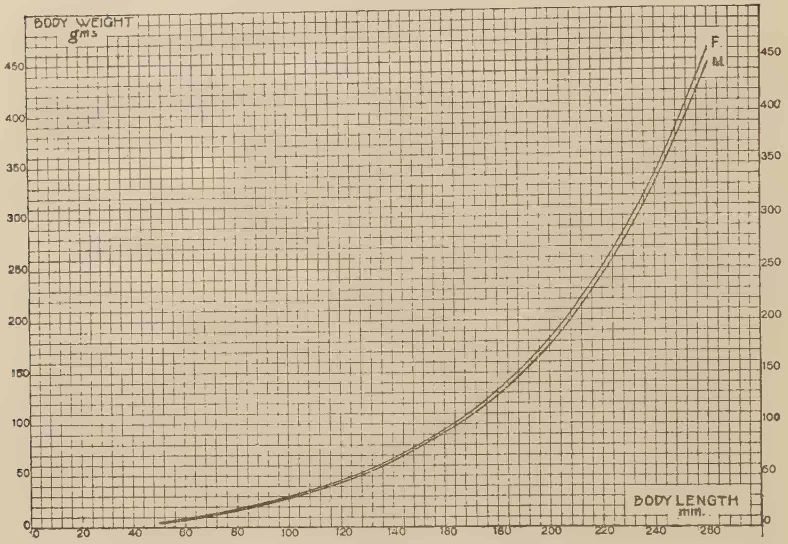

Chart 62 Giving the body weight on body length for both males and females. Formulas (54) and (55), table 187.

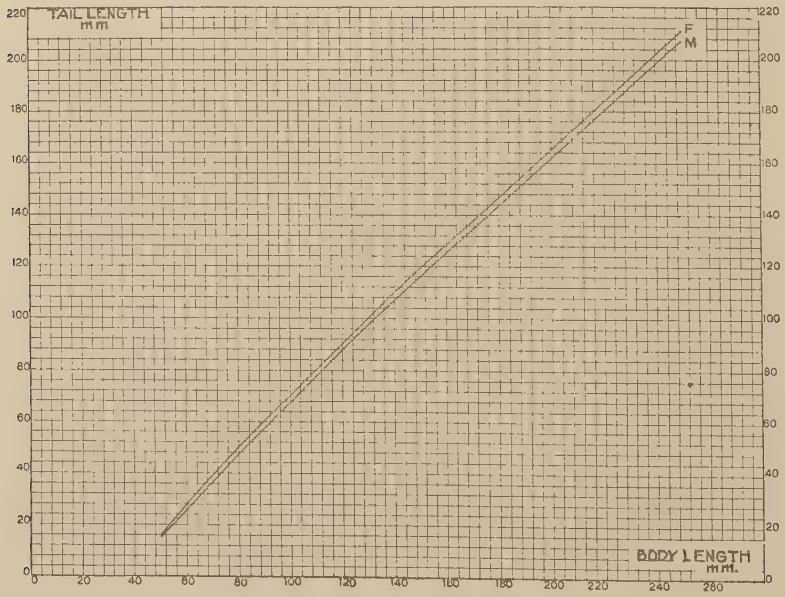

Chart 63 Norway rat—giving the tail length on the body length. Males and females. Formulas (56), (57), table 187.

This is probably an effect of domestication on the Albino. The explanation of the use of this table has been given on page 179 in connection with the corresponding table 122 for the Albino.

2. *Growth of parts of the body.* For the general conditions under which these observations were made by Jackson and Lowrey ('12), see pp. 181–182.

TABLE 188

*Giving in grams the values obtained by dividing the body weight by the body length in millimeters. Based on data in table 187*

| BODY LENGTH | RATIO | | BODY LENGTH | RATIO | | BODY LENGTH | RATIO | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | | Male | Female | | Male | Female |
| *mm.* | | | *mm.* | | | *mm.* | | |
| 50 | 0.09 | 0.09 | 120 | 0.36 | 0.37 | 190 | 0.80 | 0.82 |
| 55 | 0.11 | 0.11 | 130 | 0.41 | 0.42 | 200 | 0.89 | 0.91 |
| 60 | 0.13 | 0.14 | 140 | 0.46 | 0.47 | 210 | 0.99 | 1.02 |
| 70 | 0.17 | 0.17 | 150 | 0.51 | 0.52 | 220 | 1.10 | 1.13 |
| 80 | 0.21 | 0.21 | 160 | 0.57 | 0.59 | 230 | 1.23 | 1.27 |
| 90 | 0.24 | 0.25 | 170 | 0.64 | 0.65 | 240 | 1.37 | 1.41 |
| 100 | 0.28 | 0.29 | 180 | 0.71 | 0.73 | 250 | 1.54 | 1.58 |
| 110 | 0.32 | 0.33 | | | | 260 | 1.72 | 1.77 |

TABLE 189

*Norway rat—Percentage weights of head, trunk and extremities. Sexes combined (Jackson and Lowrey, '12)*

| SEX | NET BODY WEIGHT | HEAD | FORE LIMBS | HIND LIMBS | TRUNK |
|---|---|---|---|---|---|
| | *grams* | *per cent* | *per cent* | *per cent* | *per cent* |
| M.............. | 65.0 | 14.66 | 5.95 | 13.88 | 65.51 |
| M.............. | 95.4 | 12.17 | 5.83 | 15.34 | 66.66 |
| F.............. | 107.5 | 10.18 | 5.58 | 15.81 | 68.43 |
| M.............. | 164.0 | 9.27 | 5.24 | 14.94 | 70.55 |
| F.............. | 254.0* | 7.85 | 5.02 | 13.68 | 73.45 |

*Including gravid uterus, which weighed 13.76 grams.

Five Norways only were examined, these having been trapped in barns at the University of Missouri. They were probably living on grain. As will be seen by reference to table 189 the smallest of these, a male, weighed 65 grams and was therefore probably about seven weeks old. The percentage relations of the several parts of the body are given in table 189.

On comparing the relative values here given with those for the albino rat (see p. 183) it appears that for corresponding body weights in the Albino the average values for the fore limbs and hind limbs are low, while those for the trunk are high—a relation which might be expected in view of the greater body length of the Norway—see tables 123 and 189.

TABLE 190

*Norway rat—Percentage of total body weight represented by the weight of integument, ligamentous skeleton, musculature, viscera and remainder (Jackson and Lowrey, '12)*

| SEX | NET BODY WEIGHT | INTEGUMENT | LIGAMENTOUS SKELETON | MUSCULATURE | VISCERA | REMAINDER |
|---|---|---|---|---|---|---|
| | *grams* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| M....... | 65.0 | 18.42 | 13.15 | 35.39 | 23.40 | 9.64 |
| M....... | 95.4 | 19.29 | 13.85 | 38.57 | 23.21 | 5.08 |
| F........ | 107.5 | 20.37 | 13.86 | 42.14 | 17.51 | 6.12 |
| M....... | 164.0 | 17.35 | 13.29 | 41.66 | 20.95 | 6.75 |
| F........ | 254.0* | 19.41 | 10.16 | 44.21 | 16.22 | 10.00 |

*Including gravid uterus, which weighed 13.76 grams.

TABLE 191

*The mean weight in grams of the crania in each body weight group of the four series of wild Norway rats from Paris, London, Philadelphia, Vienna (based on table 1 Donaldson, '12 a.) Each weight group is based on six cases, 3 males and 3 females*

| BODY WEIGHT GROUP | WEIGHT OF THE CRANIA IN GRAMS | | | |
|---|---|---|---|---|
| | London | Paris | Philadelphia | Vienna |
| *grams* | | | | |
| 125............. | 1.17 | 1.27 | 1.13 | 1.10 |
| 175............. | 1.58 | 1.58 | 1.34 | 1.37 |
| 225............. | 1.84 | 1.91 | 1.71 | 1.70 |
| 275............. | 2.25 | 2.17 | 2.14 | 1.90 |
| 325............. | 2.69 | 2.60 | 2.40 | 2.27 |
| 375............. | 3.13 | 2.98 | 2.86 | 2.48 |

For the corresponding weights of the albino crania see table 133.

3. *Growth of systems.* When the values for the five entries in table 190 are compared with the last four in table 124 for the albino rat, it is noted that in the Norway the values for the musculature and viscera are high, while that for the "remainder" is low. This last difference is due possibly to the smaller amount

of fat in the Norway. At the same time there is other evidence to show that for the same body weight as the Albino, both the trunk and the viscera of the Norway are heavier, as here found.

4. *Weight of cranium.* (Donaldson, 12 a). Determinations of the weight of the cranium dried at room temperature have been made. By the cranium is meant the skull with upper teeth, minus the mandible with lower teeth and the ear bones. The mean weights are given in table 191. On comparing the values here given for the wild Norway with those for the Albino, table 133, p. 195, it is evident that for a given body weight the wild Norway has the heavier cranium.

## GROWTH IN TOTAL BODY WEIGHT ON BODY LENGTH AND GROWTH IN THE WEIGHT OF PARTS AND SYSTEMS OF THE BODY: REFERENCES

*Total body weight between birth and maturity on body length.* Donaldson and Hatai, '11. Donaldson, '12, '12 a.

*Body length on body weight.* Donaldson and Hatai, '11.

*Growth of parts.* Jackson and Lowrey, '12.

*Growth of systems.* Jackson and Lowrey, '12.

*Weight of cranium.* Donaldson, '12 a.

# CHAPTER 14

## GROWTH OF ORGANS—WILD NORWAY

1. Brain weight on body weight, (a) Comparison with albino, (b) Cranial capacity. 2. Spinal cord weight on body weight. 3. Size and shape of cerebrum, (a) Comparison with Albino. 4. Growth of cortex—thickness, (a) Comparison with Albino. 5. Growth of cortex—volume, (a) Comparison with Albino. 6. Number of cortical cells, (a) Comparison with Albino. 7. Size of cortical cells, (a) Comparison with Albino. 8. Size of sympathetic cells. 9. Weight of eyeballs. 10. Weights of ductless glands and gonads.

1. *Brain weight on body weight.* Donaldson and Hatai ('11). The direct determinations of the weight of the brain have been made on 232 males and 278 females—table 187. The general formula (58) expresses the relation of brain weight on body weight for the sexes combined.

It applies however only to rats with a body weight above 5 grams.

It has been found however (Donaldson and Hatai, '11, p. 428) that the weight of the male brain is one per cent above the mean for the two sexes, and that of the female, one per cent below.

As a consequence, each value gotten by the foregoing computations has been corrected by adding one per cent to the value found to give the weight for the male brain and by subtracting one per cent to obtain the weight for the female brain.

Chart 64 gives the graph for the male brain weight on the body weight and the corresponding graph (male) for the Albino is also drawn for comparison. The marked difference in the brain weight of the two forms is clearly shown.

(*a*) *Comparison with the albino.* Utilizing the data in tables 144 and 187 and using those for the albino male as the standards in each instance, it is found that the brain weight of the Norway male exceeds that of the Albino for the same body weight or body length by the percentages given in table 192.

It may be noted in passing that the same comparison of the data between the birth and the end of the suckling period (i.e., 25 grams or 100 mm.) shows an even greater excess in favor of the Norway.

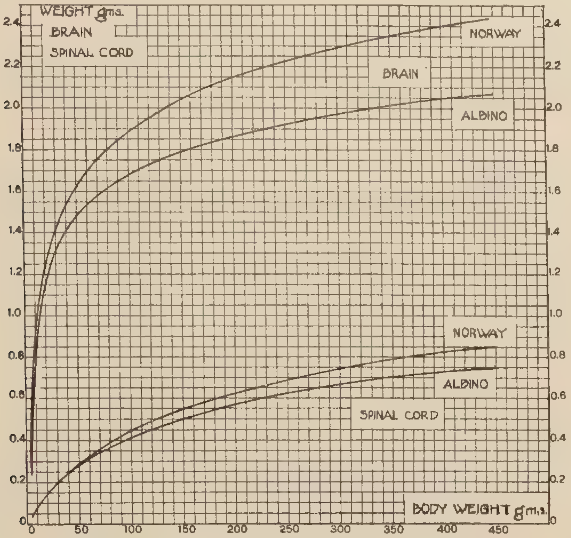

Chart 64 Norway rat, giving brain weight on the body weight. Males only. With corresponding graph for the Albino inserted for comparison. Formula 58, table 187. Also the spinal cord weight on the body weight. Males only. With the corresponding graph for the Albino inserted for comparison. Formula 60, table 187.

TABLE 192

*Giving the percentages by which the brain weight of the Norway rat exceeds that of the Albino for the like body weight or body length*

| BODY LENGTH | PERCENTAGE EXCESS OF NORWAY BRAIN | BODY WEIGHT | PERCENTAGE EXCESS OF NORWAY BRAIN |
|---|---|---|---|
| *mm.* | | *grams* | |
| 100 | 7.7 | 25 | 6.1 |
| 125 | 9.2 | 50 | 9.2 |
| 150 | 10.5 | 100 | 11.0 |
| 175 | 11.9 | 200 | 15.0 |
| 200 | 13.1 | 300 | 16.4 |
| 250 | 15.1 | 400 | 17.4 |

(*b*) *Cranial capacity.* Formula (59) gives the cranial capacity on the body weight—a useful datum in many instances.

2. *Spinal cord weight on body weight—table 187.* In the case of the spinal cord, the computation was made for the sexes combined by the aid of formula (60). Here again there is a difference according to sex, the male spinal cord exceeding the female by 0.2 per cent, and the value for both sexes combined, by 0.1 per cent. Corrections similar to those applied to the brain have been made in this case also. Chart 64 gives the graph for the male spinal cord on body weight and the corresponding graph (male) for the Albino is also drawn for comparison.

TABLE 193

*Giving the brain weight for each brain weight group, the cube root of the brain weight and the linear measurements for width, length and height of the cerebrum. Norway rat. W. B. = Width AB, W. D = Width CD, L. G = Length EG, L. F = Length EF (see figure 12). Ht. = Height HK (see figure 13)*

| BRAIN WEIGHT GROUP | NUMBER OF CASES | BRAIN WEIGHT | CUBE ROOT OF THE BRAIN WEIGHT | *W.B* | *W.D* | *L.G* | *L.F* | *Ht.* |
|---|---|---|---|---|---|---|---|---|
| | | *grams* | | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| N XI | 9 | 1.161 | 1.051 | 13.86 | 12.69 | 12.63 | 12.18 | 8.83 |
| N XII | 0 | | | | | | | |
| N XIII | 2 | 1.356 | 1.107 | 14.20 | 12.98 | 13.60 | 13.05 | 9.45 |
| N XIV | 12 | 1.436 | 1.128 | 14.45 | 13.21 | 13.71 | 13.24 | 9.31 |
| N XV | 5 | 1.536 | 1.154 | 14.77 | 13.39 | 14.18 | 13.48 | 9.28 |
| N XVI | 8 | 1.644 | 1.180 | 14.91 | 13.65 | 14.24 | 13.62 | 9.61 |
| N XVII | 8 | 1.743 | 1.204 | 15.10 | 13.92 | 14.54 | 13.88 | 9.97 |
| N XVIII | 4 | 1.836 | 1.225 | 15.17 | 14.20 | 15.00 | 14.32 | 9.98 |
| N XIX | 3 | 1.965 | 1.252 | 15.68 | 14.28 | 15.23 | 14.68 | 10.08 |
| N XX | 5 | 2.033 | 1.267 | 15.70 | 14.34 | 15.52 | 14.74 | 10.02 |
| N XXI | 4 | 2.164 | 1.293 | 16.25 | 14.94 | 15.92 | 15.12 | 10.18 |
| N XXII | 1 | 2.266 | 1.314 | 16.60 | 14.90 | 15.15 | 15.70 | 10.35 |
| N XXIII | 1 | 2.345 | 1.329 | 16.55 | 15.65 | 16.30 | 15.50 | 10.25 |

Formula (61) gives the spinal cord weight (sexes combined) on the brain weight—sexes combined.

3. *Size and shape of the cerebrum—Sugita ('18).* As in the case of the Albino, five diameters of the cerebrum were measured along the lines indicated in figures 12 and 13. The data are presented in table 193 and in chart 65.

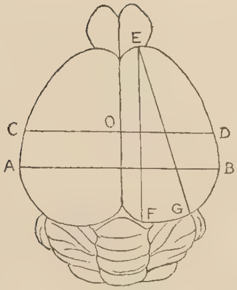

Fig. 12

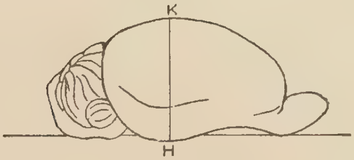

Fig. 13

Fig. 12 Dorsal view of the Norway rat brain weighing 1.64 grams—enlarged 1.8 diameters. To show the positions at which the two measurements for the width and the two measurements for the length were taken.

Fig. 13 Lateral view of the Norway rat brain weighing 1.64 grams—enlarged 1.8 diameters. To show the position at which the height was measured.

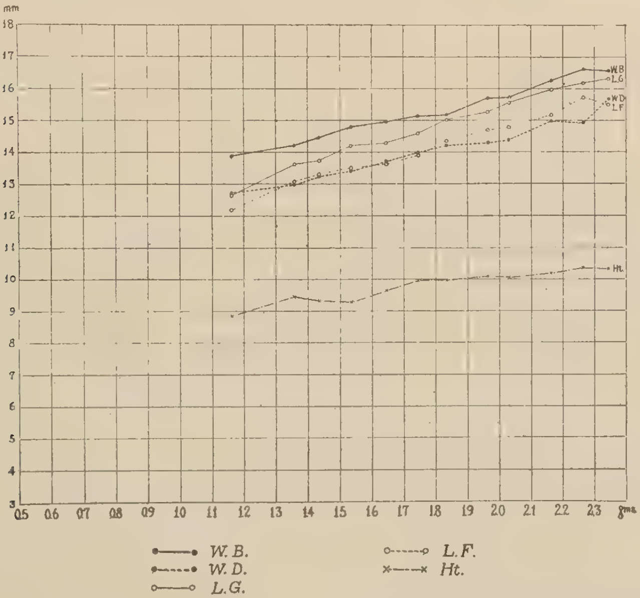

Chart 65 Giving the average values of the five diameters of the Norway rat cerebrum for each brain weight group. See legend, Chart 7.

(*a*) *Comparison with Albino.* The first records in table 193 are for brains weighing 1.16 grams from animals approximately fifteen days of age. Examination shows that the longitudinal diameters increase more rapidly than do the transverse—but comparison with the relations found in the Albino shows that the change in the form of the brain with age is less marked in the Norway—so that the Norway brain always has a rounder appearance. Furthermore, inspection of the exposed brain in the Norway shows the tips of the frontal lobes to be distinctly more rounded in them than in the Albino. The difference in the form of the cerebrum in the two strains can be brought out by comparing the linear measurements for mature brains of the same weight—table 194.

TABLE 194

*Brain diameters of Norway and Albino compared. For the designations see Table 193*

| | BRAIN WEIGHT | DIAMETERS IN MILLIMETERS | | | | |
|---|---|---|---|---|---|---|
| | | W.B. | W.D. | L.G. | L.F. | Ht. |
| | *grams* | | | | | |
| Norway........ | 2.033 | 15.70 | 14.34 | 15.52 | 14.74 | 10.02 |
| Albino......... | 2.037 | 15.39 | 14.62 | 16.65 | 15.30 | 10.02 |

4. *Growth of the cerebral cortex in thickness—wild Norway rat—Sugita ('18a).* The method of study here used was the same as that for the Albino and both the planes for the sections and the localities at which the measurements were made correspond to those shown in figures 6, 7 and 8.

The body weights were all above 17 grams. The measurements on eleven brain weight groups, when corrected for the fresh condition, give the values entered in table 195.[11]

The cortex of the Norway rat attains nearly its full thickness when the brain weighs 1.54 grams, corresponding to a body weight of 42 grams and an age of 36 days—chart 66. The average thickness at maturity is about 2.05 mm. thus exceeding that of the Albino at a like brain weight by some 8 per cent.

(*a*) *Comparison with Albino.* The relations of the cortical thicknesses are quite similar among themselves to those shown

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[11] The measurement for the frontal section is lacking in the last group—table 195 and in chart 66.

TABLE 195

*Showing the average corrected thickness of the cerebral cortex in the wild Norway rat for each brain weight group.*

| BRAIN WEIGHT GROUP | SAGITTAL SECTION | | FRONTAL SECTION | HORIZONTAL SECTION | | GENERAL AVERAGE | |
|---|---|---|---|---|---|---|---|
| | Brain weight | Thickness | Thickness | Brain weight | Thickness | Brain weight | Thickness |
| | *grams* | *mm.* | *mm.* | *grams* | *mm.* | *grams* | *mm.* |
| N XI | 1.164 | 1.61 | 1.88 | 1.164 | 1.87 | 1.164 | 1.79 |
| N XII | | | | | | | |
| N XIII | 1.369 | 1.73 | 1.96 | 1.343 | 2.08 | 1.360 | 1.92 |
| N XIV | 1.430 | 1.84 | 1.95 | 1.447 | 2.09 | 1.436 | 1.96 |
| N XV | 1.537 | 1.82 | 2.04 | 1.520 | 2.24 | 1.532 | 2.03 |
| N XVI | 1.629 | 1.88 | 2.08 | 1.663 | 2.19 | 1.640 | 2.05 |
| N XVII | 1.739 | 1.94 | 2.07 | 1.747 | 2.15 | 1.742 | 2.05 |
| N XVIII | 1.829 | 1.93 | 2.08 | 1.843 | 2.26 | 1.834 | 2.09 |
| N XIX | 1.972 | 1.97 | 2.00 | 1.953 | 2.25 | 1.965 | 2.07 |
| N XX | 2.052 | 1.87 | 1.96 | 2.018 | 2.08 | 2.041 | 1.97 |
| N XXI | 2.172 | 1.99 | 2.08 | 2.156 | 2.34 | 2.166 | 2.14 |
| N XXII | | | | | | | |
| N XXIII | 2.345 | 1.86 | — | 2.345 | 2.22 | 2.345 | 2.04 |

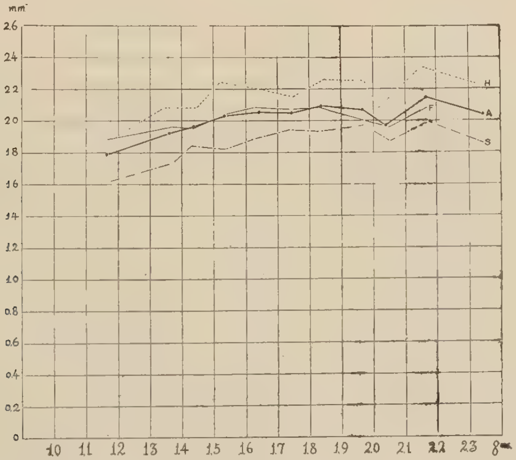

Chart 66 Giving the corrected thickness of the cortex in the sagittal, frontal and horizontal sections and the general average thickness for each brain weight group. Based on table 195. Norway rat. —·—·—S, Average thickness of the cortex in sagittal section. Corrected. ———F, Average thickness of the cortex in frontal section. Corrected. -----------H, Average thickness of the cortex in horizontal section. Corrected •———• A, General average thickness of the cortex of three kinds of sections. Corrected.

by the Albino—save that the occipital cortex is relatively thicker in the Norway. This difference appears to depend on the defective development of the visual apparatus in the Albino. Table 196.

TABLE 196

*A comparison of the cortical thicknesses at each locality and on the average, in the adult Norway and the albino brains of the same absolute weight. The measurements used here are average values of Groups NXVI–N XX and Groups XVI–XX respectively, taken from tables 4 to 6 (Sugita, '18a) and tables 6 to 8 (Sugita, '17a). The corresponding brain weights are 1.844 grams in the Norway and 1.815 grams in the Albino. The thickness of the Albino cortex is always taken as the standard for computing the percentage differences*

| SECTIONS | LOCALITIES | THICKNESS OF THE CORTEX | | CORTEX OF THE NORWAY RAT EXCEEDS BY |
|---|---|---|---|---|
| | | Norway rat | Albino rat | |
| | | *mm.* | *mm.* | *per cent* |
| Sagittal | Locality I | 2.84 | 2.80 | 1.4 |
| | II | 2.06 | 1.92 | 7.3 |
| | III | 1.82 | 1.74 | 4.6 |
| | IV | 1.51 | 1.36 | 10.0 |
| | V | 1.37 | 1.19 | 15.1 |
| | Average........ | 1.92 | 1.80 | 6.7 |
| Frontal | Locality VI | 2.11 | 1.84 | 14.8 |
| | VII | 2.28 | 2.18 | 4.6 |
| | VIII | 1.73 | 1.59 | 8.9 |
| | Average........ | 2.04 | 1.87 | 9.1 |
| Horizontal | Locality IX | 3.09 | 3.08 | 0.3 |
| | X | 2.23 | 2.06 | 8.2 |
| | XI | 2.10 | 2.04 | 3.0 |
| | XII | 1.90 | 1.71 | 11.1 |
| | XIII | 1.63 | 1.27 | 28.3 |
| | Average........ | 2.19 | 2.03 | 8.0 |
| General average................. | | 2.05 | 1.90 | 8.0 |

5. *Growth of the cerebral cortex in volume—wild Norway rat—Sugita ('18a).* Employing the same initial measurements as were made on the albino (p. 84) the relative volume of the cortex in the Norway rat has been computed and in table 197 is compared with that in the Albino on the basis of like brain weights.

(*a*) *Comparison with Albino.* Although the values given in columns G and H, table 197 are relative, they show how the volume of the cortex increases with brain weight in each strain, and the relation between the volume in the Norway and in the Albino at like brain weights. As a result of the greater thickness and area of the Norway cortex the volume exceeds that of the Albino by about 7 per cent.

TABLE 197

*Showing the computed volume for the entire cerebral cortex of the Norway rat brain, calculated by the formula: L.F. × W. D × T × C for each brain weight group, C being a fixed coefficient used to convert the computed volume of the Norway cortex so as to make it comparable with that of the Albino (C = 1.036). The computed volume of the cerebrum is quoted from my previous presentation (Sugita, '18). These values are paired with the corresponding values for the cortical volume of the Albino and the ratios between them calculated*

| NORWAY RATS | | | | | | | ALBINO RAT | |
|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I |
| Brain weight group | Brain weight | Computed volume of cerebrum *L.G × W.D×Ht.* | *L. F* in fresh brain | *W. D* in fresh brain | T.* average cortical thickness | *L. F × W. D × T × C* Computed volume of cortex | Corresponding computed volume of the Albino cortex, of the same group number | Ratio of cortical volume of the Norway to that of the Albino |
| | *grams* | *mm.*$^3$ | *mm.* | *mm.* | *mm.* | *mm.*$^3$ | *mm.*$^3$ | |
| N XI | 1.163 | 156 | 12.2 | 12.7 | 1.75 | 281.00 | 288.93 | 0.973 |
| N XII | | | | | | | 304.51 | |
| N XIII | 1.369 | 182 | 13.1 | 13.0 | 1.85 | 326.51 | 314.03 | 1.040 |
| N XIV | 1.430 | 185 | 13.2 | 13.2 | 1.90 | 343.09 | 329.71 | 1.040 |
| N XV | 1.537 | 194 | 13.5 | 13.4 | 1.93 | 361.83 | 345.86 | 1.046 |
| N XVI | 1.629 | 203 | 13.6 | 13.7 | 1.98 | 382.32 | 359.30 | 1.064 |
| N XVII | 1.739 | 218 | 13.9 | 13.9 | 2.01 | 402.47 | 365.08 | 1.102 |
| N XVIII | 1.829 | 226 | 14.3 | 14.2 | 2.01 | 423.00 | 397.96 | 1.063 |
| N XIX | 1.972 | 241 | 14.6 | 14.3 | 1.99 | 430.57 | 390.39 | 1.103 |
| N XX | 2.052 | 249 | 14.7 | 14.4 | 1.94 | 425.59 | 393.15 | 1.083 |
| N XXI | 2.172 | 264 | 15.1 | 14.9 | 2.04 | 475.66 | | |
| Average (Groups N XIII–N XX)................... | | | | | | 386.92 | 361.94 | 1.069 |

*T, here entered, is the mean value of $T_S$ and $T_F$, previously given in tables 11 and 13 and is not the general average thickness of the cortex of the sagittal, frontal and horizontal sections formerly presented in my fourth paper in this series (Sugita, '18 a).

6. *The computed number of cells in two layers of the cerebral cortex—wild Norway rat—Sugita ('18a).* Proceeding in the same manner as in the case of the Albino, see p. 83 the computed number of nerve cells in the cortex of the Norway rat was obtained at different brain weights. The data are arranged in table 198.

TABLE 198

*Giving the computed number of nerve cells in two layers of the entire cerebral cortex of the Norway rat brain, obtained on the basis of the measurements given in this series of studies. These values are made to be comparable with the corresponding values of the computed number of nerve cells in the cortex of the albino rat brains of like brain weight groups.* (*See table 48*)

| NORWAY RATS | | | | | | ALBINO RAT |
|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G |
| Brain weight group | Brain weight | Computed volume of cortex $L.F \times W.D \times T \times C$ | Sum of numbers of cells in lam. pyr. and lam. gang. in two unit volumes, $N$ | Computed number of cells in entire cortex* $N \times L.F \times W.D \times T \times C \times \frac{1}{100}$ | Ratio of number of cells in the Norway to that in the Albino | Corresponding computed number of cells in the Albino, of the same group number |
| | *grams* | *mm.*$^3$ | | | | |
| N XI | 1.163 | 281.00 | 181 | 508.6 | 0.946 | 537.4 |
| N XII | | | | | | 520.7 |
| N XIII | 1.369 | 326.51 | 166 | 542.0 | 0.981 | 552.7 |
| N XIV | 1.430 | 343.09 | 160 | 548.9 | 1.009 | 544.0 |
| N XV | 1.537 | 361.83 | 144 | 521.0 | 1.011 | 515.3 |
| N XVI | 1.629 | 382.32 | 138 | 527.6 | 1.020 | 517.4 |
| N XVII | 1.739 | 402.47 | 132 | 531.3 | 0.997 | 533.0 |
| N XVIII | 1.829 | 423.00 | 131 | 554.1 | 1.009 | 549.2 |
| N XIX | 1.972 | 430.57 | 127 | 546.8 | 1.061 | 515.3 |
| N XX | 2.052 | 425.59 | 123 | 523.5 | 1.016 | 515 0 |
| N XXI | 2.172 | 475.66 | 112 | 532.7 | | |
| Average (Groups N XIII–N XX)......... | | | | 536.9 | 1.013 | 530.2 |

*As remarked in a note to table 48 the number given in this column corresponds to 1/100 of $N \times L.F. \times W.D \times T$, or 1/50,000 of the actual number of cells contained in the computed volume of the cortex.

(*a*) *Comparison with Albino.* On examining table 198 column E, it is seen that the number of nerve cells in the cortex is nearly complete at a brain weight of 1.37 grams (Group N. XIII) while in the Albino this condition was reached at a brain weight of 1.17 grams (Group N. XI). As the last line in table 198 shows, the computed number in the Norway exceeds that in the albino by 1.3 per cent. This may be considered as practical equality, so that the number of nerve cells in the cortex of the two forms is the same, as was suggested by Donaldson and Hatai ('11). It is of interest to note that the maximum number is found in both forms at a brain weight of 1.829 gms. This corresponds to about 100 days of age in the albino. Thus a loss of cortical cells in later life is clearly indicated.

7. *Growth in the diameters of the cortical cells and their nuclei—Sugita ('18 c).* Following the same methods which were employed for the Albino (figures 9 and 10) the growth of the largest cells in unit areas of the lamina pyramidalis and the lamina ganglionaris of the cortex of the Norway rat has been determined and the results are given in table 199 and in chart 67.

(*a*) *Comparison with Albino.* If the anomalous value for the nuclei in the cells in the lamina ganglionaris of the heaviest brain is excluded from the discussion, we find approximately the same growth relations in the Norway which have been recorded for the Albino. Rapid growth comes to an end at the weaning time and after this the cells of the lamina ganglionaris continue to increase somewhat in diameter while those in the lamina pyramidalis diminish. There are however some differences. As the data show (chart 67) the end of the rapid growing period in the ganglion cells appears in the Norway a little after the corresponding period in the pyramidal cells—whereas in the Albino these relations are reversed. The cells in both layers are larger in the Norway than in the Albino. When these are compared in size for like brain weights the relations found are as in table 200.

8. *Cells in superior cervical sympathetic ganglion: Ping ('21a) Norway rat.* Using 85 individuals of which 22 were cage bred at The Institute and 63 were caught wild about Philadelphia, Ping ('21a) examined the growth of the largest cells in the superior cervical sympathetic ganglion.

These cells grow rapidly during the first 25 days after birth and then more slowly, but on *like* body weight there is no sex difference in cell size. There are somewhat more cells pigmented than in the Albino—especially in the older animals—but the amount of pig-

TABLE 199

*Giving the corrected final average diameters of the nerve cells and their nuclei in the lamina pyramidalis and the lamina ganglionaris measured on the frontal and the horizontal sections of the Norway rat brain. The average values of the two for each brain weight group are also given. The correction-coefficient for each brain weight group was taken from the previous papers (Sugita, '18 a, '18 b). F = frontal section. H = horizontal section*

| BRAIN WEIGHT GROUP | BRAIN WEIGHT | CORRECTION-COEFFICIENT | LAMINA PYRAMIDALIS |  | LAMINA GANGLIONARIS |  |
|---|---|---|---|---|---|---|
|  |  |  | Cell body diameter | Nucleus diameter | Cell body diameter | Nucleus diameter |
|  | *grams* |  | μ | μ | μ | μ |
| F N XI | 1.164 | 1.34 | 23.8 | 20.1 | 32.7 | 25.0 |
| H N XI | 1.164 | 1.30 | 23.0 | 19.1 | 31.8 | 24.2 |
|  | *1.164* |  | *23.4* | *19.6* | *32.3* | *24.6* |
| F N XIII | 1.369 | 1.33 | 23.9 | 19.8 | 33.0 | 25.5 |
| H N XIII | 1.343 | 1.39 | 24.2 | 20.3 | 33.4 | 25.6 |
|  | *1.356* |  | *24.1* | *20.1* | *33.2* | *25.6* |
| F N XIV | 1.430 | 1.35 | 24.0 | 19.7 | 34.2 | 25.5 |
| H N XIV | 1.447 | 1.36 | 24.2 | 20.3 | 33.5 | 25.9 |
|  | *1.439* |  | *24.1* | *20.0* | *33.9* | *25.7* |
| F N XV | 1.546 | 1.40 | 23.9 | 20.2 | 34.2 | 26.2 |
| H N XV | 1.520 | 1.42 | 24.5 | 20.5 | 34.5 | 26.4 |
|  | *1.533* |  | *24.2* | *20.4* | *34.4* | *26.3* |
| F N XVI | 1.629 | 1.40 | 23.8 | 19.3 | 34.7 | 25.9 |
| H N XVI | 1.663 | 1.34 | 23.2 | 19.2 | 33.5 | 25.2 |
|  | *1.646* |  | *23.5* | *19.3* | *34.1* | *25.6* |
| F N XVII | 1.739 | 1.37 | 23.8 | 19.5 | 35.1 | 26.7 |
| H N XVII | 1.747 | 1.35 | 23.4 | 19.3 | 33.5 | 25.7 |
|  | *1.743* |  | *23.6* | *19.4* | *34.3* | *26.2* |
| F N XVIII | 1.820 | 1.32 | 23.2 | 19.0 | 36.7 | 27.8 |
| H N XVIII | 1.843 | 1.39 | 23.8 | 19.7 | 34.0 | 26.0 |
|  | *1.836* |  | *23.5* | *19.4* | *35.4* | *26.9* |
| F N XIX | 1.072 | 1.33 | 22.5 | 18.8 | 38.0 | 27.9 |
| H N XIX | 1.053 | 1.34 | 23.6 | 19.8 | 35.7 | 26.5 |
|  | *1.963* |  | *23.1* | *19.3* | *36.8* | *27.2* |
| F N XX | 2.052 | 1.36 | 23.1 | 18.9 | 38.3 | 28.5 |
| H N XX | 2.018 | 1.32 | 23.9 | 19.0 | 35.6 | 25.0 |
|  | *2.035* |  | *23.5* | *19.0* | *37.0* | *26.8* |
| F N XXI | 2.172 | 1.39 | 23.5 | 19.2 | 39.6 | 28.1 |
| H N XXI | 2.156 | 1.34 | 23.5 | 18.9 | 34.8 | 26.0 |
|  | *2.164* |  | *23.5* | *19.1* | *37.2* | *27.1* |
| F N XXIII | 2.345 | 1.26 | 22.0 | 17.2 | 38.8 | 24.6 |
| H N XXIII | 2.345 | 1.28 | 22.6 | 17.4 | 36.8 | 24.1 |
|  | *2.345* |  | *22.3* | *17.3* | *37.8* | *24.4** |

*See note on table 6. (Sugita, '18 c).

ment in a given cell is not much greater. The cells are distinctly smaller than in the standard Albino (Ping, '21) of like body weight but a trifle larger than those in the inbred Albino (Ping, '21). The values are given in table 201.

A comparison of size has been made between these cells in the Norway and in two strains of Albinos—the standard strain

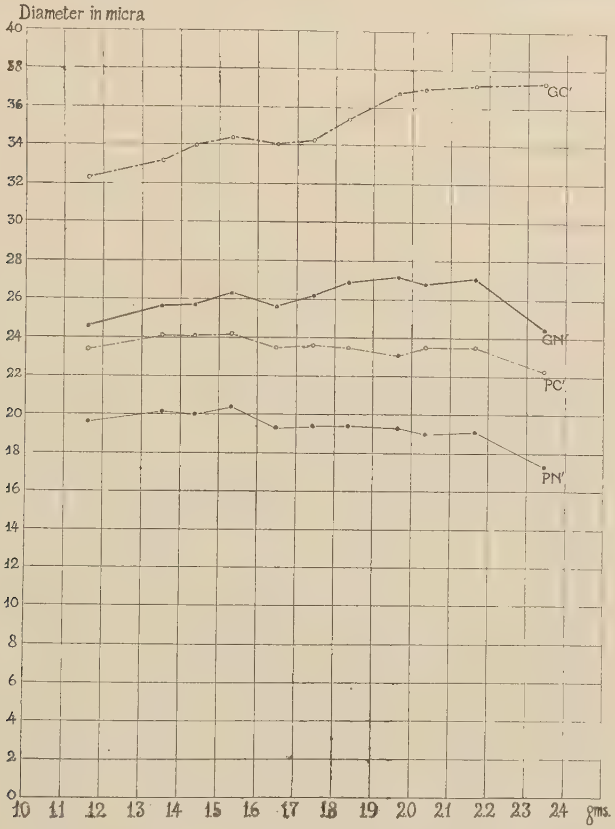

Chart 67 Showing the corrected average diameters of the cell body and the nucleus of the cortical nerve cells of the Norway rat, plotted according to increasing brain weight. Based on the data in table 199. Graph GC′, average diameter of the cell body of the ganglion cells in the lamina ganglionaris. Graph GN′, average diameter of the nucleus of the ganglion cells in the lamina ganglionaris. Graph PC′, average diameter of the cell body of the pyramids in the lamina pyramidalis. Graph PN′, average diameter of the nucleus of the pyramids in the lamina pyramidalis.

and the inbred strain of King—both reared at The Institute. The relations for two body weights are given in table 202.

TABLE 200

*Comparison of diameters of cortical cells in the Norway and the albino rats. The data used here are the averages in Groups XIII to XX and in Groups N XIII to N XX, taken from tables 3 and 8. Sugita, ('18 c). Differences in diameter and in volume are calculated here, the data of the Albino being taken as the standard of comparison*

| | AVERAGE BRAIN WEIGHT | PYRAMIDS | | GANGLION CELLS | |
|---|---|---|---|---|---|
| | | Cell body | Nucleus | Cell body | Nucleus |
| | *grams* | μ | μ | μ | μ |
| Albino.......... | 1.691 | 22.9 | 18.8 | 32.4 | 24.9 |
| Norway........ | 1.694 | 23.7 | 19.6 | 34.9 | 26.3 |
| Difference in diameter....... | | 3.5% | 4.2% | 7.7% | 5.6% |
| Difference in volume......... | | 10.9% | 13.1% | 24.9% | 17.8% |

TABLE 201

*Giving according to body weight the computed diameters of the largest cells and nuclei in the superior cervical sympathetic ganglion, of the Norway rat. Sexes separated. Data condensed. Thirteen groups*

| FORTY-THREE MALES | | | | FORTY-TWO FEMALES | | | |
|---|---|---|---|---|---|---|---|
| Number of cases | Body weight average | Computed diameter | | Computed diameter | | Body weight average | Number of cases |
| | | Nucleus | Cell | Cell | Nucleus | | |
| | *grams* | μ | μ | μ | μ | *grams* | |
| 1 | 6 | 9.9 | 17.2 | 16.5 | 9.6 | 6 | 1 |
| 3 | 15 | 12.9 | 22.8 | 22.5 | 12.5 | 14 | 3 |
| 5 | 35 | 12.4 | 23.4 | 23.2 | 11.7 | 28 | 2 |
| 3 | 76 | 13.0 | 25.5 | 25.2 | 13.0 | 31 | 1 |
| 3 | 104 | 13.1 | 26.5 | 24.3 | 12.7 | 51 | 8 |
| 2 | 117 | 13.2 | 27.1 | 26.0 | 13.0 | 73 | 2 |
| 3 | 157 | 13.3 | 26.1 | 24.9 | 13.0 | 103 | 4 |
| 3 | 186 | 13.4 | 27.9 | 28.3 | 13.3 | 157 | 4 |
| 5 | 220 | 13.6 | 29.7 | 27.7 | 13.0 | 179 | 6 |
| 4 | 244 | 14.0 | 31.3 | 26.6 | 12.8 | 192 | 3 |
| 3 | 276 | 13.5 | 33.3 | 27.8 | 12.7 | 214 | 3 |
| 5 | 323 | 14.0 | 33.0 | 31.6 | 13.7 | 227 | 2 |
| 3 | 385 | 13.7 | 31.0 | 32.1 | 13.9 | 258 | 3 |

The differences which appear in table 202 are worthy of note and especially striking is the small size of the cells in the Norway (at 200 grams) compared with that for the standard Albinos.

TABLE 202

*Giving the diameters and nucleus-plasma ratios of the standard, inbred and Norway rats according to body weight, based on previous tables. In each instance the values given are for the two sexes combined*

| STRAIN | BODY WEIGHT | DIAMETERS | | NUCLEUS-PLASMA RATIO |
|---|---|---|---|---|
| | | Cells | Nucleus | |
| | *grams* | μ | μ | |
| Standard | 145 | 28.9 | 13.2 | 1 : 9.5 |
| Inbred | 144 | 24.5 | 13.2 | 1 : 5.4 |
| Norway | 146 | 28.0 | 13.1 | 1 : 8.8 |
| Standard | 200 | 34.1 | 14.5 | 1 :12.0 |
| Inbred | 206 | 25.4 | 13.3 | 1 : 5.9 |
| Norway | 203 | 28.0 | 13.1 | 1 : 8.8 |

TABLE 203

*The weight of both eyeballs in wild Norway rats—on body length, together with weight of the eyeballs in the albino (table 144) on a body weight similar to the observed body weight Norway and to the body weight (Norway) as given in table 187 on the observed body length*

| NUMBER OF CASES | AVERAGE BODY LENGTH OBSERVED | AVERAGE BODY WEIGHT | | AVERAGE WEIGHT OF BOTH EYE-BALLS | | |
|---|---|---|---|---|---|---|
| | | | | | Albino | |
| | | Observed | In table | Norway observed | On observed Norway body weight | On Norway body weight on observed body length in table |
| | | | Males | | | |
| | *mm.* | *grams* | *grams* | *grams* | *grams* | |
| 4 | 168 | 117 | 105 | 0.229 | 0.212 | 0.202 |
| 4 | 191 | 172 | 154 | 0.242 | 0.252 | 0.239 |
| 3 | 213 | 226 | 218 | 0.244 | 0.288 | 0.281 |
| 3 | 223 | 270 | 254 | 0.260 | 0.313 | 0.304 |
| 3 | 240 | 321 | 330 | 0.282 | 0.342 | 0.347 |
| 2 | 237 | 358 | 315 | 0.311 | 0.362 | 0.340 |
| | | | Females | | | |
| 4 | 134 | 67 | 59 | 0.147 | 0.166 | 0.158 |
| 4 | 191 | 158 | 157 | 0.247 | 0.242 | 0.242 |
| 6 | 208 | 222 | 207 | 0.262 | 0.284 | 0.275 |
| 8 | 221 | 275 | 253 | 0.277 | 0.316 | 0.303 |
| 3 | 229 | 332 | 287 | 0.325 | 0.348 | 0.323 |

TABLE 204

*Showing the weights (grams) of the thyroid gland in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat*

Thyroid gland

| MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|
| Body weight | Number | Norway observed | Albino calculated | Albino calculated | Norway observed | Number | Body weight |
| 69 | 1 | 0.015 | 0.014 | 0.015 | 0.014 | 3 | 73 |
| 117 | 4 | 0.022 | 0.021 | 0.022 | 0.025 | 2 | 122 |
| 174 | 4 | 0.029 | 0.029 | 0.030 | 0.034 | 6 | 183 |
| 226 | 17 | 0.033 | 0.035 | 0.035 | 0.028 | 15 | 224 |
| 278 | 15 | 0.031 | 0.042 | 0.041 | 0.042 | 10 | 272 |
| 319 | 10 | 0.050 | 0.046 | 0.049 | 0.078 | 3 | 342 |
| 375 | 1 | 0.046 | 0.053 | | | | |
| Avg. 223 | 52 | 0.032 | 0.034 | 0.032 | 0.037 | 39 | 203 |

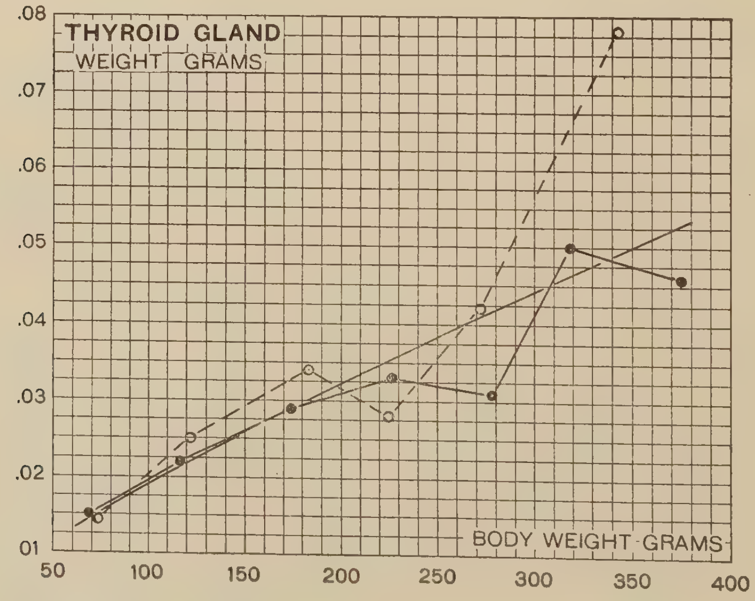

Chart 68 Showing the weight of the thyroid in the two sexes of the Norway compared with those in the albino rat.

Males • ——— • Norway, observed ○ – – – – – ○ Females
Albino, calculated ———— Both sexes.

TABLE 205

*Showing the weights (grams) of the hypophysis in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat*

Hypophysis

| MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|
| Body weight | Number | Norway observed | Albino calculated | Albino calculated | Norway observed | Number | Body weight |
| 186 | 1 | 0.0065 | 0.0071 | 0.0123 | 0.0071 | 4 | 182 |
| 226 | 14 | 0.0071 | 0.0082 | 0.0157 | 0.0086 | 9 | 225 |
| 281 | 15 | 0.0085 | 0.0097 | 0.0195 | 0.0095 | 4 | 273 |
| 315 | 1 | 0.0100 | 0.0107 | | | | |
| Avg. 252 | 31 | 0.0080 | 0.0089 | 0.0158 | 0.0084 | 17 | 227 |

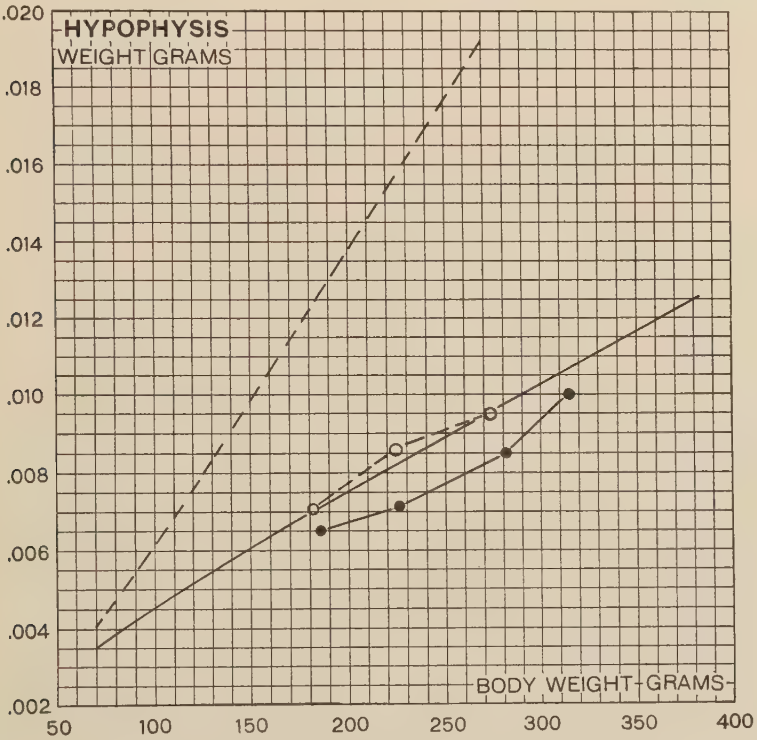

Chart 69 Showing the weight of the hypophysis in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat.

Males • ——— • Norway, observed ° - - - - - ° Females
Males ——— Albino, calculated - - - - - - Females

TABLE 206

*Showing the weights (grams) of the suprarenal glands in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat*

Suprarenal glands

| MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|
| Body weight | Number | Norway observed | Albino calculated | Albino calculated | Norway observed | Number | Body weight |
| 69 | 1 | 0.026 | 0.018 | 0.021 | 0.037 | 4 | 67 |
| 117 | 4 | 0.065 | 0.025 | 0.035 | 0.069 | 3 | 126 |
| 175 | 5 | 0.083 | 0.031 | 0.049 | 0.093 | 6 | 183 |
| 226 | 17 | 0.075 | 0.037 | 0.059 | 0.109 | 15 | 224 |
| 278 | 15 | 0.081 | 0.042 | 0.070 | 0.128 | 10 | 272 |
| 319 | 10 | 0.088 | 0.047 | 0.086 | 0.137 | 5 | 340 |
| 375 | 1 | 0.079 | 0.052 | | | | |
| Avg. 223 | 53 | 0.071 | 0.036 | 0.053 | 0.096 | 43 | 202 |

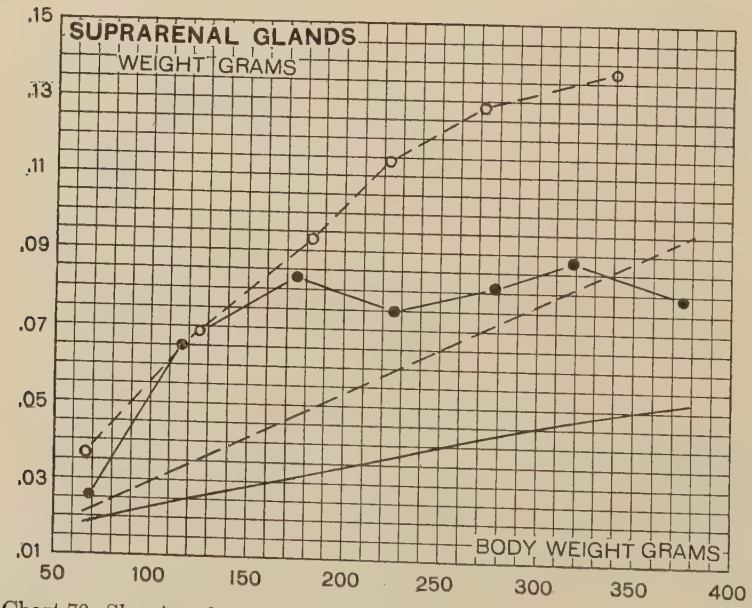

Chart 70 Showing the weight of the suprarenal glands in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat.

Males ● ——— ● Norway, observed ○ - - - - - ○ Females
Males ——— Albino, calculated - - - - - Females

9. *Weight of eyeballs—wild Norway.* A manuscript by Jackson ('11) furnishes a short series of data for the weight of the eyeballs—table 203.

Although the records in this table are few in number they show that for like body weights the eyeballs in the wild Norway are lighter than those in the Albino.

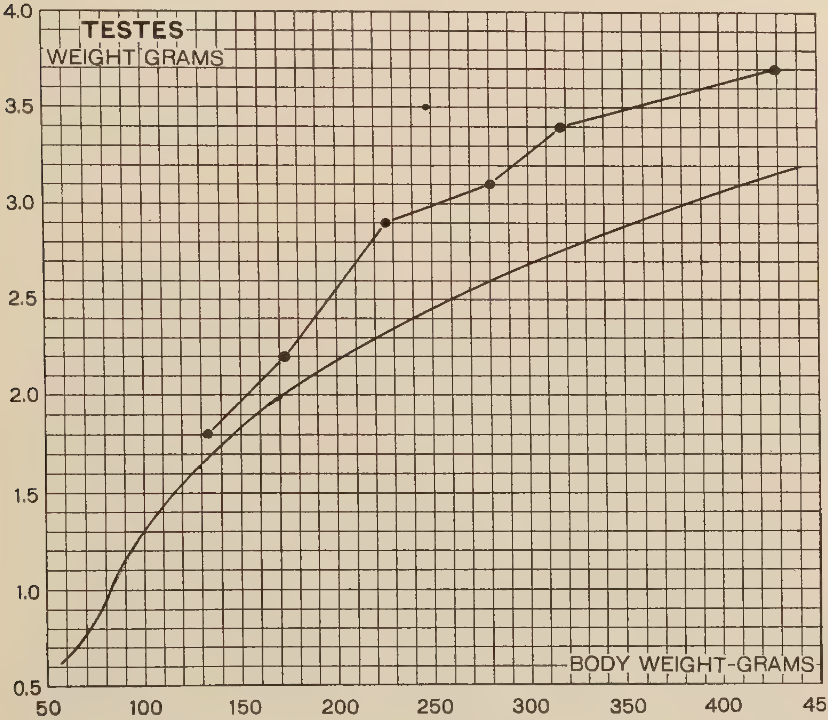

Chart 71 Showing the weight of the testes of the Norway rat compared with that of the albino rat.

Norway, observed • ——— • Albino, calculated ———

10. *Weights of the ductless glands and gonads.* Some observations on these organs have been made by Hatai (14 a) but more extensive data are needed. In this connection emphasis is put on the fact that the animals examined must be strictly wild and must not have been caged even for a few days—as the ductless glands tend to be very responsive to caging.

TABLE 207

*Showing the weights (grams) of the sex glands—testes and ovaries—in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat*

Sex glands

| MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|
| Body weight | Number | Norway observed | Albino calculated | Albino calculated | Norway observed | Number | Body weight |
| | | | | 0.010 | 0.007 | 4 | 67 |
| 133 | 5 | 1.8 | 1.7 | 0.045 | 0.036 | 5 | 126 |
| 172 | 11 | 2.2 | 2.0 | 0.048 | 0.073 | 7 | 180 |
| 226 | 16 | 2.9 | 2.3 | 0.050 | 0.075 | 21 | 221 |
| 280 | 17 | 3.1 | 2.6 | 0.051 | 0.098 | 12 | 272 |
| 317 | 8 | 3.4 | 2.8 | 0.052 | 0.063 | 6 | 337 |
| 429 | 10 | 3.7 | 3.1 | | | | |
| Avg. 260 | 67 | 2.9 | 2.4 | 0.043 | 0.059 | 55 | 201 |

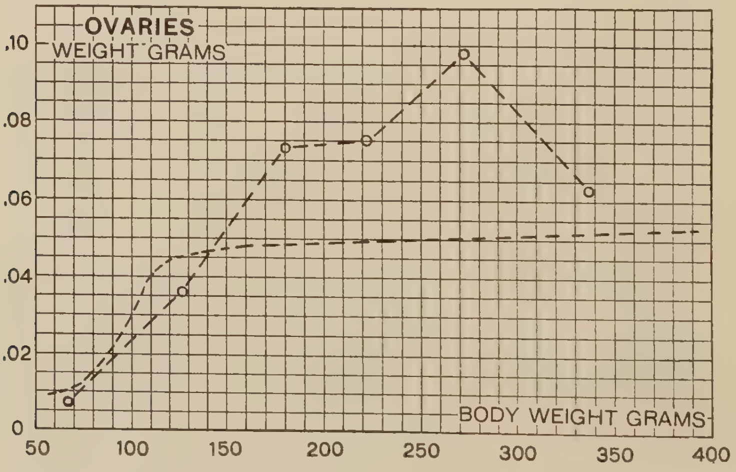

Chart 72 Showing the weight of the ovaries of the Norway compared with that of the albino rat.

Norway, observed ∘ – – – – – ∘ Albino, calculated – – – – – –

*Thyroid.* On body weight the thyroid in the wild Norway is similar in weight to that in the albino, save for the last entry for the female. The sexes are alike. Table 204 and chart 68.

*Hypophysis.* The data for the hypophysis are meagre, but a they stand, they show the hypophysis of the male Norway a slightly less in weight than that of the albino, while that of the female Norway is much below the weight of the hypophysis in the female albino and only a little above that of the male Norway. This serves to put the hypophysis weight in the female albino in high relief—table 205 and chart 69.

*Suprarenals.* The weight of the suprarenal glands in both sexes of the wild Norway runs above that for the corresponding sex in the albino—and to about the same degree—as the data in the table show. The data for this gland are not satisfactory in detail, but the general relations above indicated are trustworthy. The suprarenal weight is particularly modified by caging and domestication—table 206: chart 70. (Watson, C., '07 b.)

*Testes.* The testes are consistently heavier in the wild Norway—table 207 and chart 71.

*Ovaries.* In the case of the ovaries no valid conclusion can be drawn. As the Norway female does not breed until it is much older than the Albino, which accounts in part for the difference in the size of the ovaries up to 180 grams, and after that the wild Norways had in all probability been actively breeding while the Albinos with which they are compared were for the most part prevented from breeding—table 207 and chart 72.

## GROWTH OF ORGANS—WILD NORWAY: REFERENCES

*Brain weight on body weight.* Donaldson and Hatai, '11.
*Size and shape of cerebrum.* Sugita, '18.
*Growth of cortex—thickness.* Sugita, '18 a.
*Growth of cortex—volume.* Sugita, '18 a.
*Number of cortical cells.* Sugita, '18 a.
*Comparison with Albino.* Donaldson and Hatai, '11.
*Size of cortical cells.* Sugita, '18 c.
*Size of sympathetic cells.* Ping, '21 a.
*Weight of eyeballs.* Jackson, '11.
*Weight of ductless glands, including testes and ovaries.* Hatai, '14 a. Watson, C., '07 b.

## CHAPTER 15

## GROWTH IN TERMS OF WATER AND SOLIDS

1. Percentage of water in the blood. 2. Refractive index of serum. 3. Percentage of water in the brain and spinal cord.

1. *Percentage of water in the blood.* Hatai (MS '15) has determined the percentage of water in the blood of a small series of Norways.

The Norways had been recently caught and were examined before the day's feeding. The rat was chloroformed, but before the heart ceased beating it was exposed in situ, the tip clipped away and the blood from it caught in a small glass weighing bottle. The fresh weight was immediately taken and after drying at 95°C. for a week the weight of the residue was obtained. The results are given in table 208.

2. *Refractive index of blood serum in the wild Norway rat. Hatai '18.* The method of this determination has been given on page 64. The data are presented in table 209.

The values tend to increase with body length, here taken as an index of age. The refractive index here found is slightly below that for the Albino of the same body length. But when thus compared the Norway is probably younger, so that if it were possible to correct for age the values for the two forms might come closer together.

3. *Percentage of water in the brain and spinal cord.* Since the percentage of water in the nervous system is most closely linked with age, a precise determination in the case of the Norway rat is wanting, as the age is usually unknown. However from Norways born in captivity from trapped females we obtain the percentages according to age, given in table 210. It is to be noted that these Norways grew less rapidly than the Albinos of corresponding age, (Donaldson and Hatai '11). This observation agrees with that of King ('23).

TABLE 208

*Giving the percentage of water in the blood of the Norway rat, Hatai (MS., '15)*

| SEX | NUMBER OF CASES | BODY WEIGHT, GRAMS | | PERCENTAGE OF WATER IN BLOOD | |
|---|---|---|---|---|---|
| | | Range | Mean | Range | Mean |
| M.......... | 5 | 114–169 | 144 | 79.02–82.05 | 80.34 |
| M.......... | 6 | 173–440 | 243 | 79.92–81.53 | 80.52 |
| F........... | 4 | 103–190 | 148 | 79.82–80.35 | 80.05 |
| F........... | 5 | 199–304 | 271 | 79.52–81.77 | 80.82 |

TABLE 209

*Refractive index of blood serum of the wild Norway rats of different body lengths*

| BODY LENGTH | SEX | NUMBER | BLOOD SERUM | | REMARKS |
|---|---|---|---|---|---|
| | | | $N_D$ | $\Delta N_D$ | |
| *mm.* | | | | | |
| 136 | Mixed. | 2 | 1.34658 | 13.38 | |
| 159 | ♀ | 1 | 1.34726 | 14.06 | |
| 194 | ♂ | 1 | 1.34872 | 15.52 | |
| 240 | Mixed. | 2 | 1.34985 | 16.65 | |
| 243 | ♂ | 1 | 1.35019 | 16.99 | Slight hemolysis. |
| 256 | ♂ | 1 | 1.34985 | 16.65 | |
| Average....205 | | | 1.34874 | | |

TABLE 210

*Showing the percentage of water in the brain and spinal cord of the Norway rat at different ages (sexes combined), (Donaldson and Hatai, '11)*

| NUMBER OF CASES | AGE IN DAYS | BODY WEIGHT | PERCENTAGE OF WATER | |
|---|---|---|---|---|
| | | | Brain | Spinal cord |
| | | *grams* | | |
| 5............. | 1 | 5.1 | 88.2 | 87.0 |
| 3............. | 10 | 12.2 | 86.9 | 83.3 |
| 8............. | 13 | 18.1 | 85.3 | 82.5 |
| 6............. | 15 | 17.7 | 84.5 | 81.0 |
| 11............. | 16 | 26.1 | 82.8 | 79.4 |
| 10............. | 19 | 25.5 | 81.5 | 77.8 |
| 7............. | 25 | 32.6 | 80.9 | 76.7 |
| 4............. | 40 | 35.8 | 79.2 | 74.3 |
| 5............. | 47 | 38.5 | 79.3 | 74.0 |

For Norways trapped in Philadelphia and killed shortly after capture, we obtain, according to body weight, sexes combined, the percentage values of water in brain and spinal cord which are given in table 211.

TABLE 211

*Giving the percentage of water in the brain and spinal cord of the Norway rat according to body weight (sexes combined). Based on Donaldson and Hatai, '11, tables 11 and 14*

| BODY WEIGHT IN GRAMS | NUMBER OF CASES (SEXES COMBINED) | PERCENTAGE OF WATER (SEXES COMBINED) | |
|---|---|---|---|
| | | Brain | Spinal cord |
| 195 | 7 | 78.4 | 71.3 |
| 205 | 8 | 78.4 | 71.7 |
| 215 | 14 | 78.6 | 71.7 |
| 225 | 13 | 78.6 | 70.8 |
| 235 | 16 | 78.5 | 71.4 |
| 245 | 14 | 78.7 | 71.5 |
| 255 | 12 | 78.5 | 71.5 |
| 265 | 14 | 78.3 | 70.1 |
| 275 | 11 | 78.3 | 70.3 |
| 285 | 15 | 78.3 | 70.4 |
| 295 | 9 | 78.6 | 71.0 |
| 305 | 11 | 78.6 | 70.1 |
| 315 | 11 | 78.4 | 70.0 |
| 325 | 12 | 78.0 | 69.3 |
| 335 | 10 | 78.2 | 70.3 |
| 345 | 9 | 78.2 | 69.7 |
| 355 | 3 | 78.3 | 70.7 |
| 365 | 8 | 78.1 | 68.0 |
| 375 | 7 | 78.3 | 71.2 |
| 385 | 5 | 78.0 | 69.6 |
| 395 | 3 | 78.3 | 69.8 |
| 405 | 2 | 78.0 | 69.0 |
| 415 | 5 | 78.4 | 70.2 |
| 425 | 2 | 78.0 | 69.0 |
| 435 | | | |
| 445 | 6 | 78.5 | 69.6 |
| 455 | 1 | 78.0 | 69.0 |
| 465 | 1 | 78.0 | 67.0 |

A comparison of the values for the Norways and Albinos shows that the percentage of water in the Norways tends to run above that in the Albinos—being +0.37 per cent for the brain and +0.73 per cent for the spinal cord.

In considering the data in table 211 it must be remembered that while the percentage of water in the brain and spinal cord is primarily a function of age, yet at the same time body weight is rather poorly correlated with age. This certainly accounts for some of the irregularities which appear in this table.

The slightly higher percentage of water in the Norway nervous system is probably due in part to the greater mass of cytoplasmic substance as indicated by the slightly greater size of the cell bodies in the Norway.

### GROWTH IN TERMS OF WATER AND SOLIDS: REFERENCES

*Refractive index of serum.* Hatai, '18.

*Percentage of water in the nervous system—brain and spinal cord.* Donaldson and Hatai, '11. King, '23.

# CHAPTER 16

# CAPTIVITY AND DOMESTICATION

1. *Summary of observed changes.* Characters in which: (a) Wild Norways differ from domesticated Albinos (b) Caged and domesticated Norways differ from domesticated Albinos (c) Albinos given exercise tend to return to the Norway type.

It has been already pointed out that the albino rat is a domesticated form. To compare with it we have the pigmented Norway, which may be either wild or captive, and at the same time more or less domesticated. Captivity, represented by caging, implies physical restraint, while domestication is a matter of adjustment in behavior. For convenience, however, animals captive for several generations and more or less adjusted may be designated as domesticated, while in the first phases of captivity they may be designated as caged. The differences which appear in the composition of the two forms are referred to albinism and to domestication.

Thus far there is but one character of the Albino—the very heavy hypophysis in the female—which appears characteristic of the albino rat as an Albino, but even this character may not be due to albinism in the general sense as it does not appear in the females of the albino rabbit or guinea pig.

The other characters by which the Albino differs from the Norway are apparently the results of caging and domestication. The proof for such conclusions can be had if domestication in the Norway can be made to induce the changes which appear in the Albino or if feralization of the Albino can cause it to reassume the characters of the Norway. The later process—feralization of the Albino—is difficult to accomplish, but the domestication of the Norway presents no insuperable obstacles, though it is only now in process of accomplishment at The Institute in the hands of Dr. King.

It is possible then at the present moment to indicate:

(a) Various characters in which the wild Norway differs from the domesticated Albino.

(b) Those characters which in the caged or domesticated Norway tend to become like those of the domesticated albino and

(c) Those which—when the Albino is given some of the conditions of the wild life—exercise for instance—tend to return to the Norway type.

(a) Characters in which the wild Norway differs from the domesticated Albinos. The wild Norway is more excitable and much more savage. They gnaw their cages. The body weight is less for a given body length, hence it is a slighter animal. The skeleton is relatively heavier, also the suprarenals (both sexes) and the testes and ovaries. On the other hand the thyroid is of like weight and the hypophysis distinctly lighter, in both sexes—this difference being most marked in the female. The brain and the spinal cord are both heavier than in the Albino. The relations are illustrated by the data in table 212.

Table 212 shows that for a given body weight the wild Norway has a heavier brain both in males and in females. In all groups the difference is more marked in the males, and increases with body weight. All the foregoing relations are found in the case of the spinal cord, only the difference between the sexes is in each group more marked than in the case of the brain.

In the Norways, as compared with the Albinos, the absolute differences in weight between the sexes is distinctly greater in the case of the brain, but much less in the case of the spinal cord. This brings it about that while the cord in the Norway differs but slightly in weight according to sex, there is in the Albino a distinct sex difference—the female albino having a heavier cord than the male.

As a result of these relations it is evident that the reduction in weight due to domestication has in the Albino affected the male more than the female in both the brain and spinal cord, and that in the latter case the reduction in the male has been carried so far that the female cord is the *heavier*. This reduction in the weight of the brain and cord is accompanied by a slight diminution in the percentage of water in these parts. Such would come about if the cytoplasmic (protein) portion of the neurons was most altered, and comparison of the size of the cell bodies of the neurons in the central nervous system shows them to be smaller in the Albino than in the Norway, while the number of neurons, so far as tested, is the same in both forms.

TABLE 212

*Giving the difference in the weights of the brain and spinal cord for the wild Norway as compared with the domesticated Albino rat at a series of selected body weights*

| BODY WEIGHT | VARIETY | BRAIN WEIGHT |  | ABSOLUTE DIFFERENCE | CORD WEIGHT |  | ABSOLUTE DIFFERENCE |
|---|---|---|---|---|---|---|---|
|  |  | Males | Females |  | Males | Females |  |
| *grams* |  | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 25 | N. | 1.336 | 1.309 | −0.027 | 0.178 | 0.177 | −0.001 |
|  | A. | 1.253 | 1.234 | −0.019 | 0.176 | 0.179 | +0.003 |
|  | % Diff. | +6.6% | +6.1% |  | +1.1% | −1.1% |  |
| 50 | N. | 1.621 | 1.590 | −0.031 | 0.296 | 0.295 | −0.001 |
|  | A. | 1.485 | 1.462 | −0.023 | 0.286 | 0.290 | +0.004 |
|  | % Diff. | +9.1% | +8.7% |  | +3.5% | +1.7% |  |
| 100 | N. | 1.887 | 1.850 | −0.037 | 0.449 | 0.448 | −0.001 |
|  | A. | 1.682 | 1.657 | −0.025 | 0.415 | 0.428 | +0.013 |
|  | % Diff. | +12.2% | +11.6% |  | +8.2% | +4.7% |  |
| 200 | N. | 2.145 | 2.103 | −0.042 | 0.628 | 0.628 | 0.000 |
|  | A. | 1.867 | 1.839 | −0.028 | 0.571 | 0.583 | +0.012 |
|  | % Diff. | +14.8% | +14.1% |  | +10.0% | +7.7% |  |
| 300 | N. | 2.295 | 2.250 | −0.045 | 0.742 | 0.741 | −0.001 |
|  | A. | 1.971 | 1.941 | −0.030 | 0.665 | 0.678 | +0.013 |
|  | % Diff. | +16.4% | +15.9% |  | +11.6% | +9.3% |  |
| 400 | N. | 2.400 | 2.353 | −0.047 | 0.826 | 0.824 | −0.002 |
|  | A. | 2.044 | 2.015 | −0.029 | 0.733 | 0.748 | +0.015 |
|  | % Diff. | +17.4% | +16.7% |  | +12.7% | +10.2% |  |

In the case of the cells of the superior cervical sympathetic ganglion however the cells in the Norway are slightly smaller and show a smaller nucleus-plasma ratio.

(b) Characters in which the caged and domesticated Norways differ from the domesticated Albino. In this presentation it is to be remembered that the domestication of the Norway has been carried on by Dr. King for only a few generations, and at the moment it is but the $F_9$ which is under observation. Many of the statements to be made in this paragraph probably apply to the wild Norway also, but the full application of them must await further observations. Domesticated Norways become progressively less timid and easier to handle. They still gnaw their cages. The growth curve which in the early generations lags behind that of the Albino up to maturity tends in later generations to become more like that of the Albino. The time of suckling thus far continues somewhat longer in the Norway and the time of breeding, which in the earliest generations was at seven or eight months, appears earlier. The number of litters tends to be less than in the Albino, but the number of young per litter is about the same. The sex ratio is very low. The eyes open at 17 days.

Caging and domestication increase the body weight, but reduce the weight of the brain and spinal cord and the weights of the suprarenals and gonads. The hypophysis and thyroid are not conspicuously modified.

(c) Characters which in the Albino given exercise tend to return to the Norway type. Turning out Albinos to live the wild life in hopes that the descendents might be later examined, after a series of generations, has not been successful, though tried in several places. The liberated Albinos fail to establish themselves. In view of this result it has seemed best to try the effect of one of the elements of the wild life, namely, exercise.

When Albinos are permitted to exercise in a revolving cage within a single lifetime, the weight length relations become similar to those of the wild Norway. The percentage weight of the musculature increases. The brain increases slightly in weight, but there is no clear change in the weight of the spinal cord. The percentage of water in both of these parts is however slightly increased. The suprarenals and gonads are increased in weight, while the hypophysis tends to the relations found in the wild Norway. The viscera, except the spleen, are also increased in weight.

All of the foregoing results are from stock Albinos given exercise from about forty days of age on and do not indicate how the descendents of such rats would grow in subsequent generations. Studies on the effect of exercise through a series of generations are, however, now in progress.

# CHAPTER 17

# REFERENCES TO THE LITERATURE

1. Introduction. 2. Subject references

1. *Introduction.* The list of references which follows does not claim to be complete and in several directions is intentionally selective. For example, many bacteriological investigations in which the rat has been used are omitted, as are also a large number of descriptive papers belonging to the earlier zoölogical literature. To this list of omissions belong about a dozen titles which do not appear to be accessible in any of the larger libraries of the United States; the printing of such titles was therefore regarded as superfluous.

On the other hand, it has been my intention to include the titles of all the papers which record anatomical investigations and physiological studies, so far as these were generally available.

At the outset of such a plan one meets with the difficulty that the rat has been used in many cases where the fact is not stated in the title of the paper, and moreover in other instances it is only one of several animals which have been examined or tested.

In the selection of the titles of this class the plan has been to include everything which gave information—no matter how restricted—that applied to the rat. Of course it is inevitable under these circumstances that some papers should have been overlooked.

In accordance with the general plan of the book we have included papers not only on the wild Norway and the domesticated Albino, but also on both forms of the house rat, Mus rattus rattus and Mus rattus alexandrinus.

The specific names and designations as given by the authors are quoted without comment but can be revised by reference to the foregoing section on nomenclature. Now and then I have permitted myself an annotation when this was pertinent.

Thus far the statements apply to the literature which follows and which is arranged alphabetically by authors' names and under authors, by date.

2. *Subject references.* It was desirable at the same time to present some sort of a subject classification, and this has been done in the following manner.

At the end of each chapter, references to the literature bearing on the subject of the chapter are given by author's name and date. The full reference appears in the list at the end of the volume. The chapter lists contain not only the citations in the text, but also other references which have not been cited there. The presentation is not uniform but dictated by the arrangement of the chapter. Where possible, the references are given in alphabetical order without subdivisons, but where it will be of advantage to have the references grouped according to the sub-headings, this is done, although under this plan the same reference may appear under more than one sub-heading.

# REFERENCES TO THE LITERATURE

Entries Closed February, 1924

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